AD-A144 281 NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS 1/1
SILVER LAKE DAM (CT 0..(U) CORPS OF ENGINEERS WALTHAM
MA NEW ENGLAND DIV JUN 79

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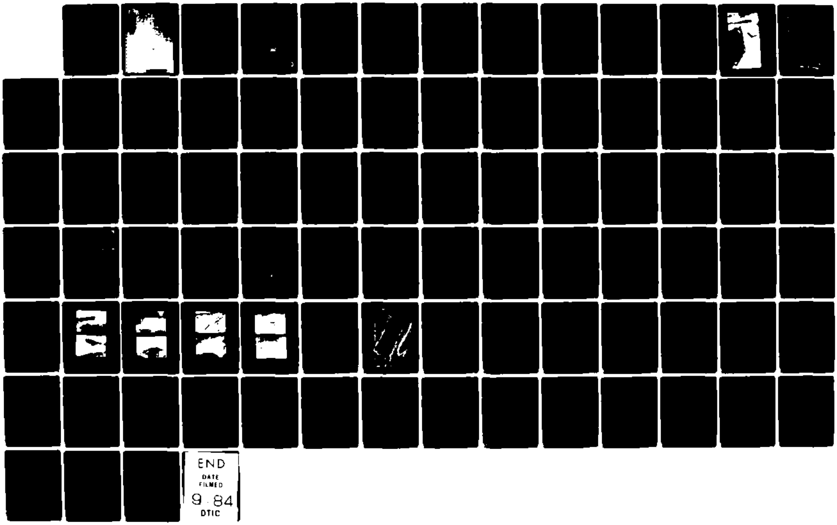

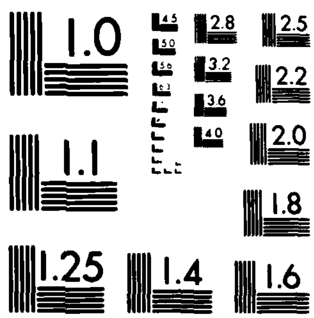

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER CT 00254	2. GOVT ACCESSION NO. A144 28	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Silver Lake Dam NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS		5. TYPE OF REPORT & PERIOD COVERED INSPECTION REPORT
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
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Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,
Connecticut River Basin
Berlin, Connecticut

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The 140 ft. long dam is an earth embankment, the top of which, at elevation 154.5, is approximately 15 ft. above the streambed of Belcher Brook. Based on the visual inspection at the site and past performance, the dam is judged to be in very poor condition. Based upon the size (intermediate) and hazard classification (significant) of the dam in accordance with Corps of Engineers Guidelines, the test flood will be equivalent to one-half the Probable Maximum Flood.

CONNECTICUT RIVER BASIN

BERLIN, CONNECTICUT

SILVER LAKE DAM
CT 00254

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

JUNE 1979

BRIEF ASSESSMENT

PHASE I INSPECTION REPORT

NATIONAL PROGRAM OF INSPECTION OF DAMS

Name of Dam:	SILVER LAKE DAM
Inventory Number:	CT 00254
State Located:	CONNECTICUT
County Located:	HARTFORD
Town Located:	BERLIN
Stream:	BELCHER BROOK
Owner:	STATE OF CONNECTICUT
Date of Inspection:	APRIL 3, 1979
Inspection Team:	CALVIN GOLDSMITH
	PETER HEYNEN, P.E.
	THEODORE STEVENS
	GONZALO CASTRO, P.E.
	MOSHE' NORMAN
	KATHLEEN MEDESKA

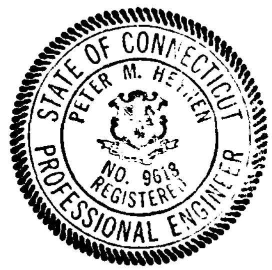
The 140 foot long dam is an earth embankment, the top of which, at elevation 154.5, is approximately 15 feet above the streambed of Belcher Brook. A drop inlet at a flow line elevation about 4.5 feet below the top of the dam, is the spillway facility. A wooden gate extending the full 7.5 foot depth of the structure is the low level outlet, however it is apparently stuck in a closed position. The inlet structure feeds an arched brick culvert which has an estimated chord length of 7 feet and an effective depth of approximately 3 feet, due to heavy siltation. A recent partial collapse of the brick culvert where it abuts the downstream low-level outlet headwall caused partial blockage of the culvert as well as an approximately six foot wide cavity and sloughing to the crest of the dam on the downstream slope. Upon being informed of the situation by the Corps of Engineers, immediate temporary repairs were performed by the owner (State of Connecticut) by bridging from the brick culvert to the back of the headwall with large stones and then filling the excavated hole on the slope with sandbags (See March 26, 1979 Cahn Engineers Memorandum in Appendix B).

Based on the visual inspection at the site and past performance, the dam is judged to be in very poor condition. Evidence of instability was noted in the form of a collapse of the outlet conduit and a subsequent failure of the downstream slope of the dam. There are other areas requiring attention as well.

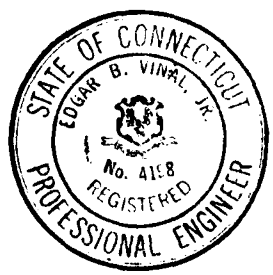
Based upon the size (Intermediate) and hazard classification (Significant) of the dam in accordance with Corps of Engineers Guidelines, the test flood will be equivalent to one-half the Probable Maximum Flood (PMF). Peak inflow to the lake is 1700 cfs; peak outflow is 250 cfs with the dam overtopped 0.3 feet. Based upon the hydraulics computations, the spillway capacity is 180 cfs to the top of the dam, which is equivalent to 72% of the routed test flood outflow.

It is recommended that further studies be undertaken to perform a more refined hydraulic/hydrologic study to determine the best way to increase the project discharge. The present drop inlet spillway is easily subject to blockage, and therefore should be redesigned. Recommendations should also be made to provide an easily operable, properly sized low level outlet facility through the dam. The present low level outlet gate should be repaired immediately upon receipt of this report to provide a means of lowering the lake level in the interim period until the low level outlet is redesigned and constructed. The *recommendations* for the redesign of the spillway and low level outlet should encompass the removal and/or repair of the partially collapsed brick conduit and the undermined concrete headwall, as well as the repair of the erosion and sloughing of the downstream slope above the headwall.

The above recommendations, and the remedial measures recommended, both of which are discussed in Section 7, should be undertaken immediately upon the owner's receipt of this report.



Peter M. Heynen, P.E.
Project Manager
Cahn Engineers, Inc.



Edgar B. Vinal, Jr., P.E.
Senior Vice President
Cahn Engineers, Inc.

This Phase I Inspection Report on Silver Lake Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

CHARLES G. TIERSCH, Chairman
Chief, Foundation and Materials Branch
Engineering Division

FRED J. RAVENS, Jr., Member
Chief, Design Branch
Engineering Division

SAUL C. COOPER, Member
Chief, Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspection. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam would necessarily represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions will be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions there of. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as neccessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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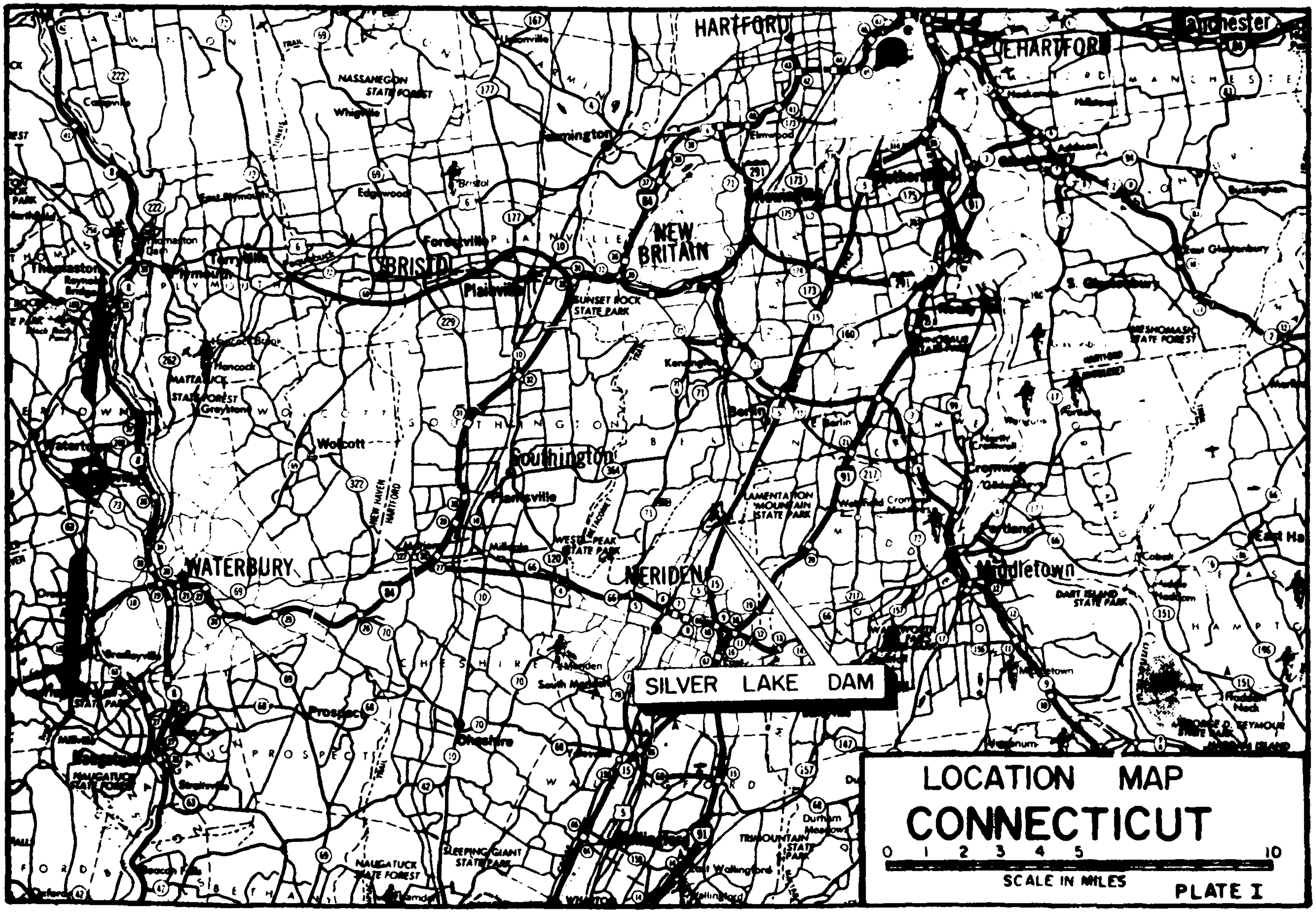
APPENDICES

OVERVIEW PHOTO
(MARCH, 1979)

US ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.	NATIONAL PROGRAM OF	SILVER LAKE DAM	BERLIN	DATE June '79
[illegible] ENGINEERS INC	INSPECTION OF NON-FED DAMS	BELCHER BROOK	[illegible]	CE # 27 595 [illegible] PAGE VIII


HARTFORD
E. HARTFORD
Manchester
NEW BRITAIN
BRISTOL
Plainville
Forestville
Southington
WATERBURY
MERIDEN
Middletown
Wolcott
Cheshire
Prospect
SILVER LAKE DAM
NASSAHEGON STATE FOREST
SUNSET ROCK STATE PARK
LAMENTATION MOUNTAIN STATE PARK
WEST PEAK STATE PARK
MESHOMASIC STATE FOREST
DART ISLAND STATE PARK
NAUGATUCK STATE FOREST
SLEEPING GIANT STATE PARK
TRIMOUNTAIN STATE PARK
LOCATION MAP
CONNECTICUT
0 1 2 3 4 5 10
SCALE IN MILES
PLATE I

PHASE I INSPECTION REPORT

SILVER LAKE DAM

SECTION I - PROJECT INFORMATION

1.1 GENERAL

a. Authority - Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Cahn Engineers, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Connecticut. Authorization and notice to proceed were issued to Cahn Engineers, Inc. under a letter of November 28, 1978 from Max B. Scheider, Colonel, Corps of Engineers. Contract No. DACW 33-79-3-0014 has been assigned by the Corps of Engineers for this work.

b. Purpose of Inspection Program - The purposes of the program are to:

1. Perform technical inspection and evaluation of non-federal dams to identify conditions requiring correction in a timely manner by non-federal interests.

2. Encourage and prepare the States to quickly initiate effective dam inspection programs for non-federal dams.

3. To update, verify and complete the National Inventory of Dams.

c. Scope of Inspection Program - The scope of this Phase I inspection report includes:

1. Gathering, reviewing and presenting all available data as can be obtained from the owners, previous owners, the state and other associated parties.

2. A field inspection of the facility detailing the visual condition of the dam, embankments and appurtenant structures.

3. Computations concerning the hydraulics and hydrology of the facility and its relationship to the calculated flood through the existing spillway.

4. An assessment of the condition of the facility and corrective measures required.

It should be noted that this report does not pass judgement on the safety or stability of the dam other than on a visual basis. The inspection is to identify those features of the dam which need corrective action and/or further study.

1.2 DESCRIPTION OF PROJECT

A. Location - The dam is located on Belcher Brook in a rural area of the Town of Berlin, County of Hartford, State of Connecticut. The dam is shown on the Meriden USGS Quandrangle Map having coordinates latitude N 41°35.2' and longitude W 72°46.2'.

b. Description of Dam and Appurtenances - The 140 foot long dam is an earth embankment, the top of which at elevation 154.5, is approximately 15 feet above the estimated original streambed of Belcher Brook. The upstream slope, inclined at 3 horizontal to 1 vertical, is partially protected by unevenly dumped rock riprap to about 1.5 feet above the normal pool elevation of 150. Brush is growing on the upstream slope along the right portion of the dam. The typically 10 foot wide crest of the dam is covered by a heavy growth of grass except for a dirt footpath which runs the length of the dam. The downstream slope, inclined approximately at 2 horizontal to 1 vertical is generally covered by thick, thorny brush. A failure of the downstream slope due to undermining and sloughing occured sometime between the cursory inspection of the dam on Jan. 26. 1979 and the discovery of the failure on March 23, 1979. (Appendix B-8) The collapse of an approximately one foot long section of the arch brick culvert through the dam caused undermining resulting in an approximately six foot wide by four foot deep hole in the downstream slope. (Appendix C, photos 5 and 6) The slope failure was temporarily repaired on March 24, 1979 by bridging the gap between the collapsed conduit and a downstream concrete headwall with large stones and filling the hole with sandbags. This brick conduit is the only outlet at the dam leading from a 7.5 foot square concrete drop inlet spillway, which has on its upstream side an apparently immovable wooden low level inlet gate. It is not known if the dam has a corewall, nor is it known what the dam is founded upon.

c. Size Classification - INTERMEDIATE - The dam impounds 1480 acre - feet of water with the lake level at the top of the dam, which at elevation 154.5 is 15 feet above the estimated original streambed. According to the Recommended Guidelines, this dam is classified as intermediate in size.

d. Hazard Classification - SIGNIFICANT - The dam is located approximately 6,000 feet upstream of two houses located just below Gills Pond and only 3 to 4 feet above the streambed of Belcher Brook. If the dam were to breached, there is potential for loss of life and property damage at the initial impact area described above, and possibly at one structure further downstream on Four Rod Road.

e. Ownership - State of Connecticut
Department of Environmental Protection
Region 1 Headquarters
P.O. Box 161
Pleasant Valley, CT 06063
Mr. Anthony Cantelle (203) 379-0771

The State acquired Silver Lake, which was then also known as Peat Works Pond, including the dam, from the Southern New England Realty Company in 1937.

f. Operator - None

g. Purpose of Dam - Recreational

h. Design and Construction History - According to the National Inventory of Dams, Silver Lake Dam is estimated to have been built in 1920. The headwall at the toe of the dam would then appear to post-date the original dam construction as it is inscribed with the date "Sept. 24 '42". Also, according to a small write-up of the lake by the Fish and Waterlife Unit of the State Department of Environmental Protection, the dam was repaired in 1961. Nothing specific concerning the nature of the repairs was given, however Mr. Cantelle of the State of Connecticut speculated that perhaps the concrete of the drop inlet was resurfaced. No other information was available.

i. Normal Operational Procedures - There do not appear to be any operational procedures followed for the dam, as the only regulatory outlet is the gate which appears to be stuck in a closed position.

1.3 PERTINENT DATA

a. Drainage Area - 2.0 square miles of fairly extensively developed rolling to flat terrain.

b. Discharge at Damsite - Both the drop inlet and, if it were moveable, the wooden low level gate, discharge through a heavily silted arched brick culvert type conduit.

1. Outlet Works (conduits):	One 7' wide by 3' high culvert @ Invert El. 140.0±
2. Maximum known flood at damsite:	N/A
3. Ungated spillway capacity @ top of dam el. 154.5:	180 cfs.
4. Ungated spillway capacity @ test flood el.:	N/A ?
5. Gated spillway capacity @ normal pool el.:	N/A
6. Gated spillway capacity @ test flood el.:	N/A
7. Total spillway capacity @ test flood el.:	N/A ?
8. Total project discharge @ test flood el. 154.8:	250 cfs.

c. Elevations (Feet Above Mean Sea Level)

1. Streambed @ centerline of dam:	140.0+
2. Maximum tailwater:	N/A
3. Upstream portal invert diversion tunnel:	N/A
4. Recreation pool:	150 (assumed)
5. Full flood control pool:	N/A
6. Spillway crest :	150 (assumed)
7. Design surcharge (original design):	N/A

8. Top of dam: 154.5

9. Test flood design surcharge: 154.8

d. <u>Reservoir</u>

1. Length of maximum pool: 5200+ ft.

2. Length of recreation pool: 5200 ft.

3. Length of flood control pool: N/A

e. <u>Storage</u>

1. Recreation pool: 670 acre-ft.

2. Flood control pool: N/A

3. Spillway crest pool: 670 acre-ft.

4. Top of dam: 1480 acre-ft.

5. Test flood pool: 1530 acre-ft.

f. <u>Reservoir Surface</u>

1. Recreation pool: 151 acres

2. Flood control pool: N/A

3. Spillway crest: 151 acres

4. Test flood pool: 180 acres

5. Top of dam: 180 acres

g. <u>Dam</u>

1. Type: Earthen embankment with concrete drop inlet to discharge conduit.

2. Length: 140± ft.

3. Height: 15± ft.

4. Top width: 10 ft.

5.	Side Slopes:	3 H to 1 V upstream 2 H to 1 V downstream
6.	Zoning:	N/A
7.	Impervious core:	N/A
8.	Cutoff:	N/A
9.	Grout curtain:	N/A
10.	Other:	N/A

h. <u>Diversion and Regulating Tunnel</u> N/A

1. Type:
2. Length:
3. Closure:
4. Access:
5. Regulating facilities:

i. <u>Spillway</u>

1.	Type:	Broad-crested concrete drop inlet
2.	Length of weir:	7.5' x 7.5' sq. (inner dimensions)
3.	Crest elevation:	150
4.	Gates:	One: on upstream face
5.	Upstream channel:	N/A
6.	Downstream channel:	Conduit to natural Streambed
7.	General:	N/A

j. <u>Regulating Outlets</u> - The single regulating outlet is a wooden slide gate on the upstream face of the drop inlet.

1.	Invert:	Not determined
2.	Size:	2.8' wide, 7.5' high

3. Description:	Wooden gate
4. Control mechanism:	None
5. Other:	Stuck in closed position

SECTION 2: ENGINEERING DATA

2.1 DESIGN

a. Available Data - The available data, all of which is included in Appendix B, consists of Inventory Data by the State of Connecticut Water Resources Commission and an inspection report by Edward F. Ahneman Jr. of S.E. Minor & Co., Inc. dated July 15, 1974.

b. Design Features - The inventory data and inspection report indicate the design features noted in Section 1.

c. Design Data - There were no engineering values, assumptions, test results or calculations available for the original construction or subsequent construction.

2.2 CONSTRUCTION

a. Available Data - No data was available.

b. Construction Considerations - No information was available other than the memorandum concerning temporary repairs to the dam dated March 26, 1979 (B-8).

2.3 OPERATIONS

To our knowledge, the dam spillway capacity has never been exceeded. Lake level readings are never taken and no formal operations procedures are known to exist, however a bathymetric map, showing the lake bottom contours of Silver Lake, was available from the Fish and Waterlife Unit of the State Department of Environmental Protection (B-3).

2.4 EVALUATION

a. Availability - Existing data was provided by the Owner. The Owner made the facility available for visual inspection.

b. Adequacy - The limited amount of detailed engineering data available was generally inadequate to perform an in-depth assessment of the dam, therefore, the final assessment of this dam must be based primarily on visual inspection, performance history, hydraulics computations of spillway capacity and approximate hydrologic judgements.

c. Validity - A comparison of record data and visual observations reveals no observable significant discrepancies in the record data.

SECTION 3: VISUAL INSPECTION

3.1 FINDINGS

a. General - The general condition of the dam is very poor. The lake level was approximately one inch above the spillway crest at the time of our inspection.

b. Dam

Crest - The crest of the dam is 10 feet wide and at elevation 154.5 is fairly level along its entire length (Appendix C, Photos 1 and 2). Vegetation consists of a heavy growth of grass and weeds. A narrow footpath exists along the entire length of the crest. The crest grades evenly into a gravel roadway at the left end of the dam and is cut off abruptly at the right end by a steep (1 H to 2 V±) wooded slope. On the crest of the dam at the base of the right abutment slope are two rather large (15" to 20" diameter) tree stumps (Photo 4), the dead or dying roots of which may cause seepage through the dam.

Upstream slope - The upstream slope is generally inclined on a 3 horizontal to 1 vertical slope and is partially protected to an elevation approximately 1.5 feet above the spillway crest by unevenly dumped trap rock riprap (Photo 1). Large bushes and small trees are growing along a portion of the upstream slope between the drop inlet structure and the right abutment. The rest of the slope is generally covered with wild grass and weeds. Minor sloughing was observed.

Downstream Slope - The downstream slope is inclined at 2 horizontal to 1 vertical and covered by a thick growth of thorny brush (Photo 2). Sometime around February or March of 1979 the slope failed in the area immediately upstream of the concrete headwall structure resulting in a hole of up to 6 feet across at the top that tapered down to about 1 foot across at the bottom (Photos 5 and 6). Before temporary repairs were undertaken, water could be seen flowing under the bottom of the hole from the outlet conduit into the headwall structure. Apparently the brick arch culvert had collapsed immediately upstream of the headwall for a distance of approximately a foot. This collapse exposed the water flowing in the conduit which in turn carried away the soil above it in the embankment slope. Undermining of the embankment resulted in the hole as well as slumping on the downstream slope continuously up to the crest of the dam.

The slope failure was discovered on March 23, 1979 and temporarily repaired the following day as recorded on pages B-8 to B-10. Temporary repairs consisted of excavating the area upstream of the headwall thus exposing the back of the headwall and the brick conduit structure, bridging the gap between the headwall and the brick structure with large stones and filling the excavation and slope failure with sandbags (Photo 7). At the time of our inspection on April 3, 1979, the repairs appeared to be intact and no further undermining was observed. At the time of this writing, the owner had been inspecting the repair work regularly and reported that it appeared to remain in good condition, the only minor problem being the removal of some of the sandbags, probably by children playing in the area.

At the toe of the slope is a generally marshy area, however an especially wet condition exists at the toe at the right and left ends of the dam. The condition may be due to seepage through the dam and possibly associated with the large tree stumps at the right abutment, however no point of exit of seepage from the dam was detected

c. Appurtenant Structures

Spillway - The spillway is a 7.5 feet by 7.5 feet (inside measurement) square concrete drop inlet structure with a one foot wide crest at an elevation 4.5 feet below the top of the dam (Photo 3). A three foot high pipe railing along the crest surrounds the inlet shaft which is approximately 7.5 feet deep. At its base, where debris such as rocks and sticks seems to be collecting, the shaft discharges through an approximately 40 foot long brick arch culvert which has a maximum width (chord) of 7 feet. The conduit, at least at the outlet, is silted so that its actual shape and size are unknown, however from rough measurements at the inlet under overflowing conditions, it is estimated that the maximum height of the conduit is approximately three feet. The conduit discharges into Belcher Brook at a concrete headwall structure at the toe of the dam (Photo 8). The concrete is generally in good condition with some cracking observed, however the structure is being undermined. The undermining is most noticable along the downstream wingwalls on either side of the outlet. At the abutment of the brick conduit with the concrete headwall a portion of the conduit collapsed and it has been temporarily repaired, as previously described.

Low Level Gate - A wooden slide gate exists on the upstream face of the drop inlet structure (Photo 3). The gate is apparently stuck in a closed position blocking an opening 2.8 feet wide and presumably as high as the shaft (± 7.5'). The gate was apparently designed to slide up and down in slots in the concrete. Bolted to the top of the wooden gate is an iron plate upon both ends of which are welded short sections of six inch diameter steel pipe. These pipes were apparently meant to serve as catches to which a winch cable looped over the railing could be attached in order to lift the gate. The gate is rendered immovable by the fact that there is only one bolt left holding the iron plate onto the wooden gate.

d. Reservoir Area - Silver Lake is located in a naturally marshy area between two fairly steep ridges, possibly rendering the already shallow lake susceptible to further sedimentation. Several residential and commercial developments, which could potentially be affected by backwaters from the dam, are present along the eastern and southern shores of the lake.

e. Downstream Channel - Immediately downstream of the dam, Belcher Brook meanders slightly to the right and flows approximately 250 feet through a marshy area before passing through a culvert under a gravel road. In the marshy area immediately downstream of the dam, a few clumps of small trees have been uprooted and fallen in the stream channel.

3.2 EVALUATION

Based upon the visual inspection, the dam is generally in very poor condition. The following features which could influence the future condition and/or stability of the dam were identified.

1. The discharge conduit is partially collapsed on its downstream side. Under full flows, undermining and sloughing of the temporarily repaired downstream slope is likely to occur again. The partial collapse of the conduit gives rise to doubts about the stability of the remainder of the brick culvert. Further collapse of the culvert would be a definite threat to the stability of the dam.

2. The lack of an operational low level outlet gate prohibits the regulation of the lake level should the need arise.

3. The sedimentation in the discharge conduit decreases its flow capacity.

4. The upstream slope is poorly protected against erosion and has suffered some minor sloughing.

5. The undermining of the headwall at the conduit discharge could lead to a deterioration of its structural soundness and alignment.

6. Wet areas at the right and left toes of the dam could be due to seepage which could increase in flow, possibly compromising the stability of the dam.

7. The trees and saplings on the upstream and downstream slopes could present problems in the future if allowed to grow unchecked. The two tree stumps at the right end of the crest of the dam will deteriorate possibly providing seepage paths via the root systems during high water conditions.

SECTION 4: OPERATIONAL PROCEDURES

4.1 REGULATING PROCEDURES

Lake level readings are not taken and there is no operable outlet to regulate the water level in the reservoir.

4.2 MAINTENANCE OF DAM

The dam is checked for littering and vandalism as part of the owner's periodic routine patrol of nearby boat launching facilities. Other than the clearing of debris from near the drop inlet, there is apparently no maintenance performed on the dam. No technical inspection program had ever been in effect until the dam required temporary repair work this spring. Since that time, the owner has been inspecting the dam usually every ten days, or more often during periods of heavy rainfall, to check the condition of the repaired area.

4.3 MAINTENANCE OF OPERATING FACILITIES

The low level outlet gate is apparently stuck and in need of maintenance. To the best of ourknowledge, the last time the lake was drawn down was in 1961. The gate has probably not been operated and/or maintained since that time.

4.4 DESCRIPTION OF ANY FORMAL WARNING SYSTEM IN EFFECT

No formal warning system is in effect.

4.5 EVALUATION

The operation and maintenance procedures are nearly non-existent. A formal program of operation and maintenance procedures should be implemented, including documentation to provide complete records for future reference. Also, a formal warning system should be developed and implemented within the time frame indicated in Section 7.1c. Remedial operation and maintenance recommendations are presented in Section 7.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. General - The dam is basically a high surcharge storage - low spillage type project. In fact, the surcharge storage is greater than the storage at the normal pool elevation. The approximate one mile length of the lake provides a large wave fetch and, if strong winds were to be out of the south during times of high water, significant wave action could be generated against the unprotected upstream slope of the dam.

b. Design Data - No computations could be found for the original dam construction.

c. Experience - It does not appear the dam has been overtopped. The maximum height of water over the spillway is not known.

d. Visual Observations - The capacity of the spillway discharge conduit has been reduced due to siltation. Potentially, the already damaged conduit could be totally blocked if the temporary repairs were to fail or if the conduit were to suffer further collapse. In times of severe weather and high water, the drop inlet/conduit would be highly susceptible to partial or total blockage by floating logs or debris.

e. Test Flood Analysis - The test flood for this significant hazard, intermediate size dam is equivalent to one-half the Probable Maximum Flood (PMF). Based upon "Preliminary Guidance for Estimating Maximum Probable Discharges", dated March, 1978, peak inflow to the reservoir is 1700 cfs (Appendix D-1), peak outflow is 250 cfs with the dam overtopped 0.3 feet (D-11). Based upon the hydraulics computations, the spillway capacity is 180 cfs, which is approximately 72% of the routed Test Flood outflow at the top of dam, elevation 154.5 (D-11).

f. Dam Failure Analysis - Utilizing the April, 1978 "Rule of Thumb Guidance for Estimating Downstream Dam Failure Hydrographs", the peak failure outflow from the dam breaching would be 4100 cubic feet per second. A breach of the dam would result in a rise on the order of 4 feet of the water level in the downstream channel, which corresponds to an increase in the water level from a depth on the order of 2 feet just before the breach to a depth on the order of 6 feet just after the breach (D-15). The rapid rise in the water level would probably affect the two houses at the initial impact area near Gills Pond, and could also possibly affect one structure about 2000 feet further downstream near where Belcher Brook crosses Four Rod Road.

SECTION 6: STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations - Based on our visual inspections, the dam stability appears to be very poor in the area above the brick arch culvert. The partial collapse of the culvert adjacent to the downstream concrete headwall caused the severe sloughing and undermining of the downstream slope. The sandbag repairs will suffice for a short period of time, but permanent repairs are needed in the very near future.

The stability of the wingwalls of the concrete headwall is also in question due to deterioration and undermining of the walls observed at the flow line elevation.

b. Design and Construction Data - No design or construction data was available for this dam.

c. Operating Records - There are no operating records for this dam. Prior to the recent culvert and slope collapse, there was no information on problem situations at the dam other than the siltation of the conduit mentioned in the inspection report of July 1974. As noted in Section 3, the siltation condition still exists.

d. Post Construction Changes - Reportedly, the dam was constructed in 1920, and the concrete headwall was added in September of 1942 according to the inscription on the headwall. There is a very brief mention of repairs to the dam in 1961, but what repairs were performed is not known. It was speculated that perhaps the concrete of the drop inlet was resurfaced. Also, at some time after construction, 2 large trees at the right end of the crest of the dam were cut down leaving the stumps that are there presently.

e. Seismic Stability - The dam is in Seismic Zone 1 and according to the Recommended Guidelines, need not be evaluated for seismic stability.

SECTION 7: ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Condition - Based upon the visual inspection of the site and its past performance, the dam appears to be in very poor condition. Evidence of structural instability was observed in the brick arch culvert and concrete headwall. The embankment is generally in poor condition with several areas of concern. There are some areas requiring attention, such as the spillway configuration and capacity, the partially collapsed brick conduit and resultant slope failure, the partially undermined outlet headwall, the inoperable low level gate, the inadequate operations and maintenance procedures, the siltation of the discharge conduit, the wet areas at the toe of the dam, the lack of adequate upstream slope protection and the two large tree stumps on the crest at the right abutment.

Based upon "Preliminary Guidance for Estimating Maximum Probable Discharges" dated March, 1978, peak inflow to the lake is 1700 cfs; peak outflow is 250 cfs with the dam overtopped 0.3 feet. Based upon the hydraulics computations, the spillway capacity is 180 cfs, which is equivalent to approximately 72% of the routed Test Flood outflow.

b. Adequacy of Information - The information available is such that an assessment of the condition and stability of the dam must be based solely on visual inspection, past performance of the dam, and sound engineering judgement.

c. Urgency - It is recommended that the measures presented in section 7.2 and 7.3 be undertaken immediately upon the owner's receipt of this report.

d. Need for Additional Information - There is a need for more information as recommended in Section 7.2.

7.2 RECOMMENDATIONS

1. A registered professional engineer qualified in dam design should prepare plans and specifications for the immediate repair or replacement of the brick discharge conduit and concrete headwall, as well as for the repair of the undermining, severe erosion and sloughing of the downstream slope of the dam. As the present drop inlet spillway is easily subject to blockage, consideration should be given to improving the spillway configuration. Sizing of any revised spillway configuration should be in accordance with the recommendation of Section 7.2.2, below.

2. Based upon the computations in Appendix D, the dam spillway capacity will be exceeded by the Test Flood. More sophisticated flood routing should be undertaken by hydrologists/hydraulics engineers to refine the spillway design flood figures. A study should be undertaken and recommendations made to increase the project discharge based upon the refined spillway design flood figures.

3. A registered professional engineer qualified in dam design also should prepare plans for construction of an easily operable, properly sized low level outlet facility through the dam.

4. A registered professional engineer qualified in dam inspection should develop a program to monitor the apparent seepage at the downstream toe of the dam, complete with written and photographic records for future reference. An evaluation of the significance of the apparent seepage should be undertaken, and if deemed necessary, measures taken for its control or elimination. The engineer should also supervise both the removal of the 2 large tree stumps at the right end of the dam, and the proper backfilling of the resulting excavation.

7.3 REMEDIAL MEASURES

a. Operation and Maintenance Procedures - The following measures should be undertaken within the time frame indicated in Section 7.1c, and continued on a regular basis where applicable.

1. Round-the-clock surveillance should be provided by the owner during periods of unusually heavy precipitation. The owner should develop a formal warning system with local officials for alerting downstream residents in case of an emergency.

2. A formal program of operation and maintenance procedures should be instituted and fully documented to provide accurate records for future reference.

3. A program of inspection by a registered professional engineer qualified in dam inspection should be instituted on an annual basis. The inspection should be technical in nature and should include the operation of the low level outlet works.

4. Riprap should be replaced on the upstream slope of the dam to the crest. Prior to placing the riprap, the minor sloughing of the upstream slope should be repaired and all trees and brush on the upstream slope should be removed. Trees and brush on the downstream slope should also be removed.

5. If the brick conduit is to be incorporated into the redesign of the spillway, it should be regularly maintained to keep it clear of sedimentation.

6. The low level outlet gate should be repaired upon receipt of this report to provide an effective means to control the water level in the lake.

7.4 ALTERNATIVES

This study has identified no practical alternatives to the above recommendations and remedial measures.

APPENDIX A

INSPECTION CHECKLIST

VISUAL INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT SILVER LAKE DAM

DATE: 4/3/79

TIME: 2:00 PM

WEATHER: OVERCAST, DRIZZLE, 50°

W.S. ELEV. 150.1± U.S. ______ DN.S

PARTY:	INITIALS:	DISCIPLINE:
1. CALVIN GOLDSMITH	CG	CAHN ENGINEERS INC.
2. THEODORE STEVENS	TS	CAHN ENGINEERS, INC.
3. PETER HEYNEN	PH	CAHN ENGINEERS, INC.
4. GONZALO CASTRO	GC	GEOTECHNICAL ENGINEERS, INC.
5. MOSHÉ NORMAN	–	SURVEYOR
6. KATHLEEN MEDESKA	–	SURVEYOR

PROJECT FEATURE	INSPECTED BY	REMARKS
1. EARTH DAM EMBANKMENT	CG, TS, GC, PH	
2. WOODEN SLIDE GATE	CG, TS	
3. BRICK CULVERT	CG, TS, GC, PH	
4. OUTLET HEADWALL	CG, TS, GC, PH	
5. OUTLET WORKS	CG, TS, GC, PH	
6.		
7.		
8.		
9.		
10.		
11.		
12.		

PERIODIC INSPECTION CHECK LIST

Page A-2

PROJECT SILVER LAKE DAM DATE 4/3/79

PROJECT FEATURE EARTH DAM EMBANKMENT BY CG, TS, GC, PH

AREA EVALUATED	CONDITION
DAM EMBANKMENT	
Crest Elevation	154.5±
Current Pool Elevation	150.1±
Maximum Impoundment to Date	NOT KNOWN
Surface Cracks	NONE OBSERVED
Pavement Condition	N/A
Movement or Settlement of Crest	NONE OBSERVED
Lateral Movement	TOO IRREGULAR TO JUDGE
Vertical Alignment	
Horizontal Alignment	
Condition at Abutment and at Concrete Structures	LARGE STUMPS @ RIGHT ABUTMENT ROAD @ LEFT ABUTMENT SLOPE FAILURE @ ABUTMENT W/ OUTLET HEADWALL
Indications of Movement of Structural Items on Slopes	N/A
Trespassing on Slopes	FOOTPATH ALONG CREST
Sloughing or Erosion of Slopes or Abutments	MAJOR EROSION OF D/S SLOPE MINOR SLOUGHING OF U/S SLOPE
Rock Slope Protection-Riprap Failures	RIPRAP SPARSE IN PLACES
Unusual Movement or Cracking at or Near Toes	NONE OBSERVED
Unusual Embankment or Downstream Seepage	NONE OBSERVED, GENERALLY WET CONDITION @ TOE
Piping or Boils	NONE OBSERVED
Foundation Drainage Features	N/A
Toe Drains	
Instrumentation System	

PERIODIC INSPECTION CHECK LIST

Page A-3

PROJECT Silver Lake Dam DATE 4/3/7?

PROJECT FEATURE Wooden Slide Gate BY CG, TS

AREA EVALUATED		CONDITION
OUTLET WORKS-INTAKE CHANNEL AND INTAKE STRUCTURE		
a) Approach Channel		NO CHANNEL VISIBLE
Slope Conditions		PROBABLY SILTY LAKE BOTTOM
Bottom Conditions		
Rock Slides or Falls		
Log Boom		
Debris		ROCKS AND STICKS IN DROP INLET
Condition of Concrete Lining		N/A
Drains or Weep Holes		N/A
b) Intake Structure		
Condition of Concrete		APPEARS FAIR - DIFFICULT TO SEE - SUBMERGED, ALGAE GROWTH
Stop Logs and Slots		WOODEN GATE - APPEARS TO BE STUCK IN CLOSED POSITION - ONLY ONE BOLT LEFT HOLDING IRON PLATE TO GATE COULD NOT OBSERVE SLOTS

PERIODIC INSPECTION CHECK LIST

Page A-4

PROJECT SILVER LAKE DAM DATE 4/3/79

PROJECT FEATURE ARCH BRICK CULVERT BY CG, TS, GC, PH

AREA EVALUATED		CONDITION
OUTLET WORKS-TRANSITION AND CONDUIT		
General Condition of ~~Concrete~~ Brick		POOR - UNDERMINED, PARTIALLY COLLAPSED, SILTED IN
Rust or Staining on ~~Concrete~~ Brick		MOSS, ALGAE GROWTH
Spalling		N/A
Erosion or Cavitation		YES - UNDERMINED SLIGHTLY ALONG BOTH SIDES
Cracking		MINOR
Alignment of Monoliths		N/A
Alignment of Joints		N/A
Numbering of Monoliths		N/A

PERIODIC INSPECTION CHECK LIST

Page A-5

PROJECT Silver Lake Dam DATE 4/3/79

PROJECT FEATURE Concrete Outlet Headwall BY CG, TD, GC, PH

AREA EVALUATED		CONDITION
OUTLET WORKS-OUTLET STRUCTURE AND OUTLET CHANNEL		
General Condition of Concrete		GOOD
Rust or Staining		NONE OBSERVED
Spalling		NONE, ONE CHIP OUT OF LEFT WINGWALL
Erosion or Cavitation		BOTH WINGWALLS UNDERMINED
Visible Reinforcing		NONE OBSERVED
Any Seepage or Efflorescence		NONE OBSERVED
Condition at Joints		N/A
Drain Holes		N/A
Channel		NATURAL STREAM BED
Loose Rock or Trees Overhanging Channel		SMALL CLUMPS OF SAPLINGS FALLEN INTO CHANNEL
Condition of Discharge Channel		SHALLOW, SANDY SILT BOTTOM

PERIODIC INSPECTION CHECK LIST

Page A-6

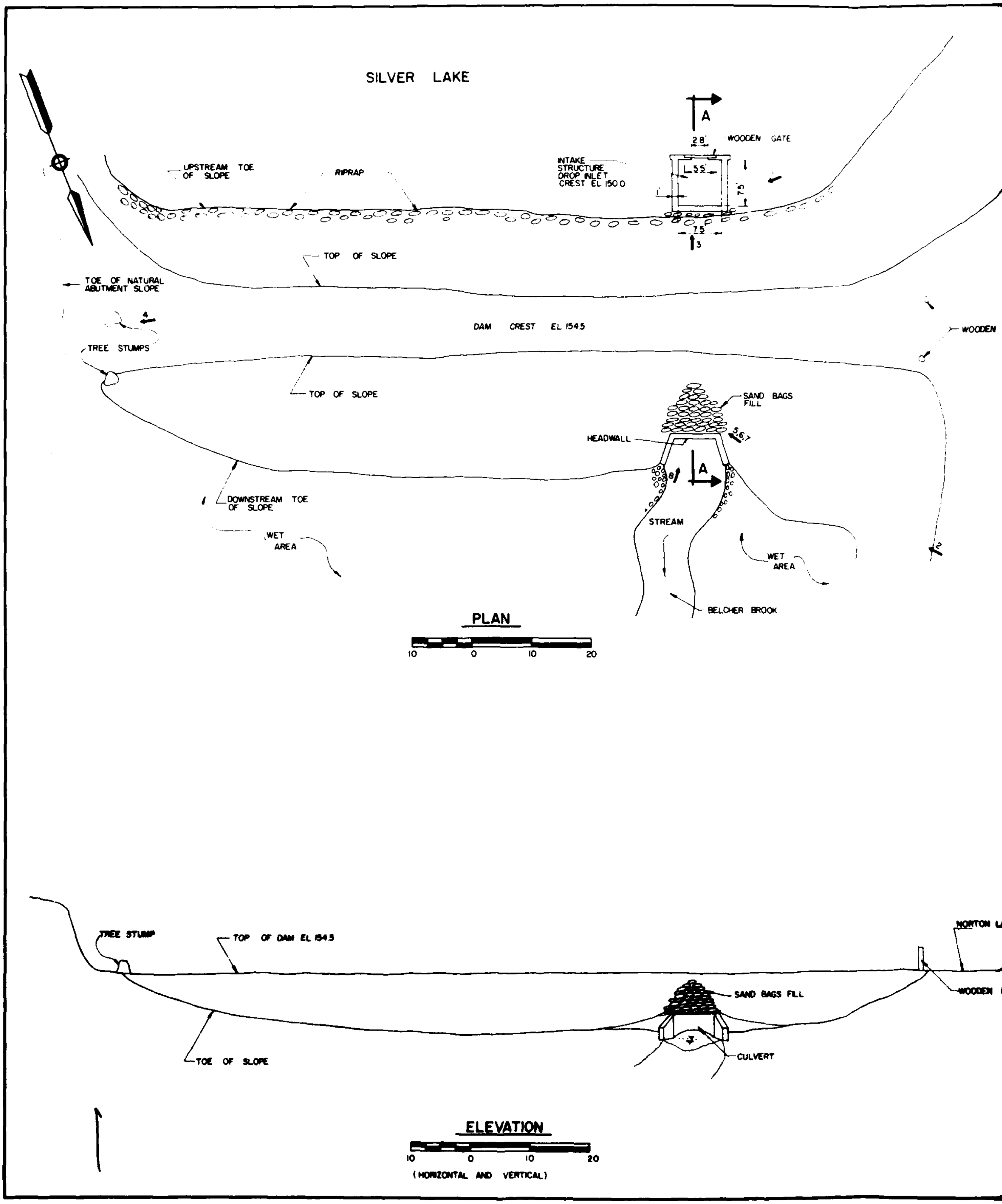
PROJECT Silver Lake Dam DATE 4/3/79

PROJECT FEATURE Outlet Works BY CG, TS, GC, PM

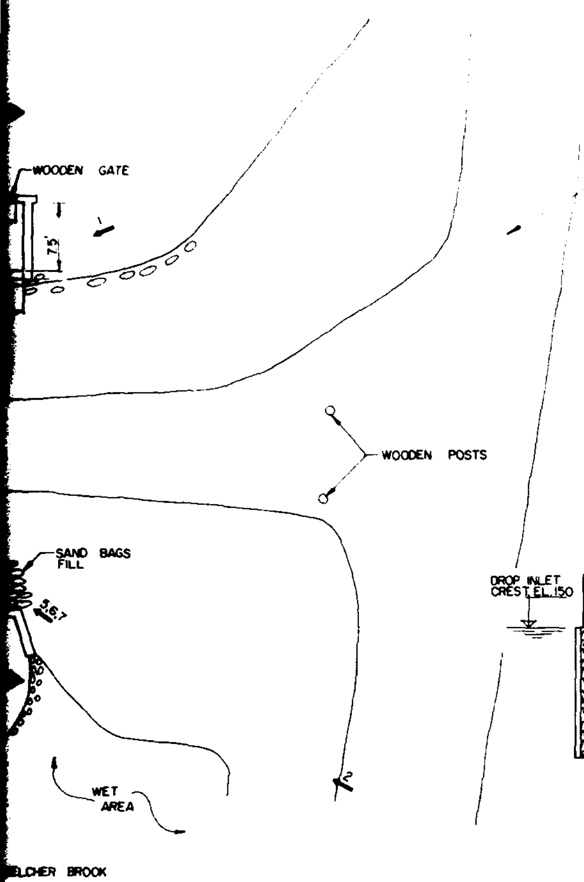
AREA EVALUATED	CONDITION
OUTLET WORKS-SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a) Approach Channel	NO APPROACH CHANNEL
General Condition	
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Approach Channel	
b) Weir and ~~Training Walls~~ Drop Inlet	DROP INLET 7.5' x 7.5' (INSIDE DIM.)
General Condition of Concrete	APPEARS GOOD
Rust or Staining	ALGAE GROWTH
Spalling	NONE OBSERVED
Any Visible Reinforcing	
Any Seepage of Efflorescence	
Drain Holes	
c) Discharge Channel	BRICK ARCH CULVERT TO STREAM
General Condition	POOR - PARTIALLY COLLAPSED
Loose Rock Overhanging Channel	NONE OBSERVED
Trees Overhanging Channel	NONE OBSERVED
Floor of Channel	SILT & SAND
Other Obstructions	CHANNEL AND CULVERT SILTED IN

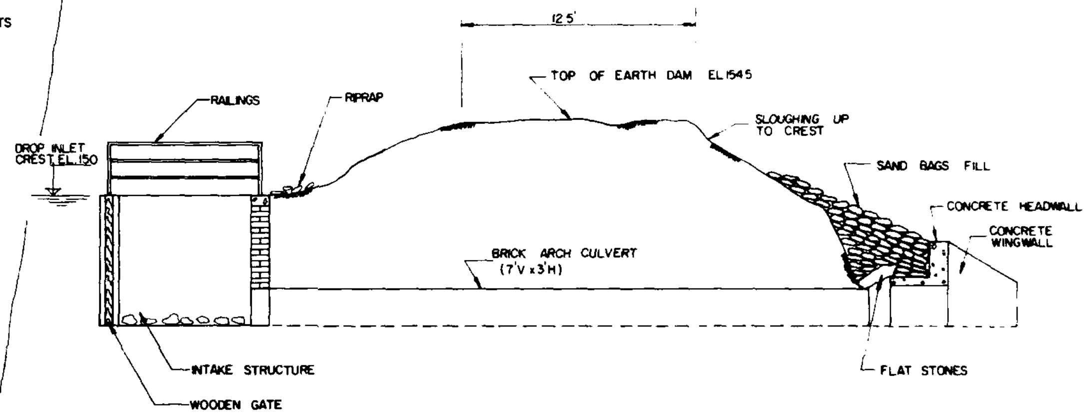
APPENDIX B

ENGINEERING DA"A AND CORRESPONDENCE



SILVER LAKE
A
2.8'
WOODEN GATE
INTAKE STRUCTURE DROP INLET CREST EL 150.0
5.5'
7.5'
7.5'
3
UPSTREAM TOE OF SLOPE
RIPRAP
TOP OF SLOPE
TOE OF NATURAL ABUTMENT SLOPE
4
TREE STUMPS
DAM CREST EL 154.5
WOODEN
TOP OF SLOPE
SAND BAGS FILL
HEADWALL
5,6,7
8
A
DOWNSTREAM TOE OF SLOPE
STREAM
WET AREA
WET AREA
2
BELCHER BROOK
PLAN
10 0 10 20
TREE STUMP
TOP OF DAM EL 154.5
NORTON L
SAND BAGS FILL
WOODEN
CULVERT
TOE OF SLOPE
ELEVATION
10 0 10 20
(HORIZONTAL AND VERTICAL)





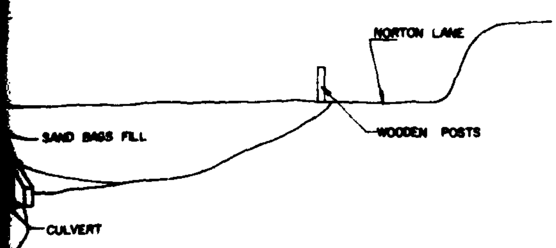
SECTION A-A

5 0 5 10

(CROSS-SECTION OF OUTLET WORKS SHOWING TEMPORARY REPAIRS)

NOTES

1. THIS PLAN WAS COMPILED FROM ROUGH FIELD SURVEY ONLY. NO PLANS FOR THE DAM WERE AVAILABLE. DIMENSIONS SHOWN ARE APPROXIMATE AND NOT ALL STRUCTURAL AND/OR TOPOGRAPHIC FEATURES ARE IDENTIFIED.
2. ELEVATIONS SHOWN ARE RELATIVE TO AN ASSUMED INTAKE STRUCTURE CREST ELEVATION TAKEN TO BE THE SAME AS THE WATER SURFACE ELEVATION OF SILVER LAKE SHOWN ON THE MERIDEN U.S.G.S QUADRANGLE MAP.
3. TEMPORARY REPAIRS WERE PERFORMED BY THE STATE OF CONNECTICUT APPROXIMATELY AS SHOWN ON MARCH 24, 1979 TO STABILIZE THE DOWNSTREAM SLOPE IN THE VICINITY OF THE OUTLET WORKS.
4. $\xleftarrow{2}$ PICTURE NUMBER AND DIRECTION



2

CAHN ENGINEERS INC. WALLINGFORD, CONNECTICUT ENGINEER			U.S ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS	
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS				
SILVER LAKE DAM				
BELCHER BROOK			BERLIN, CONNECTICUT	
DRAWN BY	CHECKED BY	APPROVED BY	SCALE AS NOTED	
N.N.	CRG	PnH	DATE: MAY 1979	PLATE - 2

SUMMARY OF DATA AND CORRESPONDENCE

DATE	TO	FROM	SUBJECT	PAGE
April 13 1964	Files	Water Resources Commission, Supervision of Dams	Inventory Data	B-2
1971	Files	State of Connecticut Department of Environmental Protection	Lake bottom contour map with descriptive narrative	B-3
July 15,	State of Conn. Dept. of Environ-mental Protection	S.E. Minor & Co., Inc.	Inspection Report and Recommendations	B-5
March 26, 1979	Files	Calvin Goldsmith Cahn Engineers, Inc.	Memo concerning discovery of slope failure and subsequent repairs	B-8
May 14, 1979	Victor F. Galgowski Water and Related Resources, Dept. of Environmental Protection	Peter M. Heynen, P.E. Cahn Engineers, Inc.	Preliminary Hydraulic/ Hydrologic Recommendations	B-11

No. B-10 1-27

WATER RESOURCES COMMISSION
SUPERVISION OF DAMS
INVENTORY DATA

10

CT-254

Inventoried By WPS

Date 13 APRIL 1964

Name of Dam or Pond SILVER LAKE

Code No. C 28.5 M 11.4 BL 3.4

Nearest Street Location NORTON LANE

Town BERLIN Long 72-46.1

U.S.G.S. Quad. MERIDEN Lat 41-35.2

Name of Stream BELCHER BROOK

Owner STATE OF CONNECTICUT

Address HARTFORD

Pond Used For RECREATION

Dimensions of Pond: Width 1500 FEET Length 4500 FEET Area ~~164~~ 143.2 ACRES 64

Total Length of Dam 130 FEET Length of Spillway 6 FEET BY 6 FEET

Location of Spillway WEST END OF DAM

Height of Pond Above Stream Bed 8 FEET

Height of Embankment Above Spillway 4 FEET

Type of Spillway Construction CONCRETE DROP INLET, 8' square

Type of Dike Construction EARTH, RIP-RAP UPSTREAM

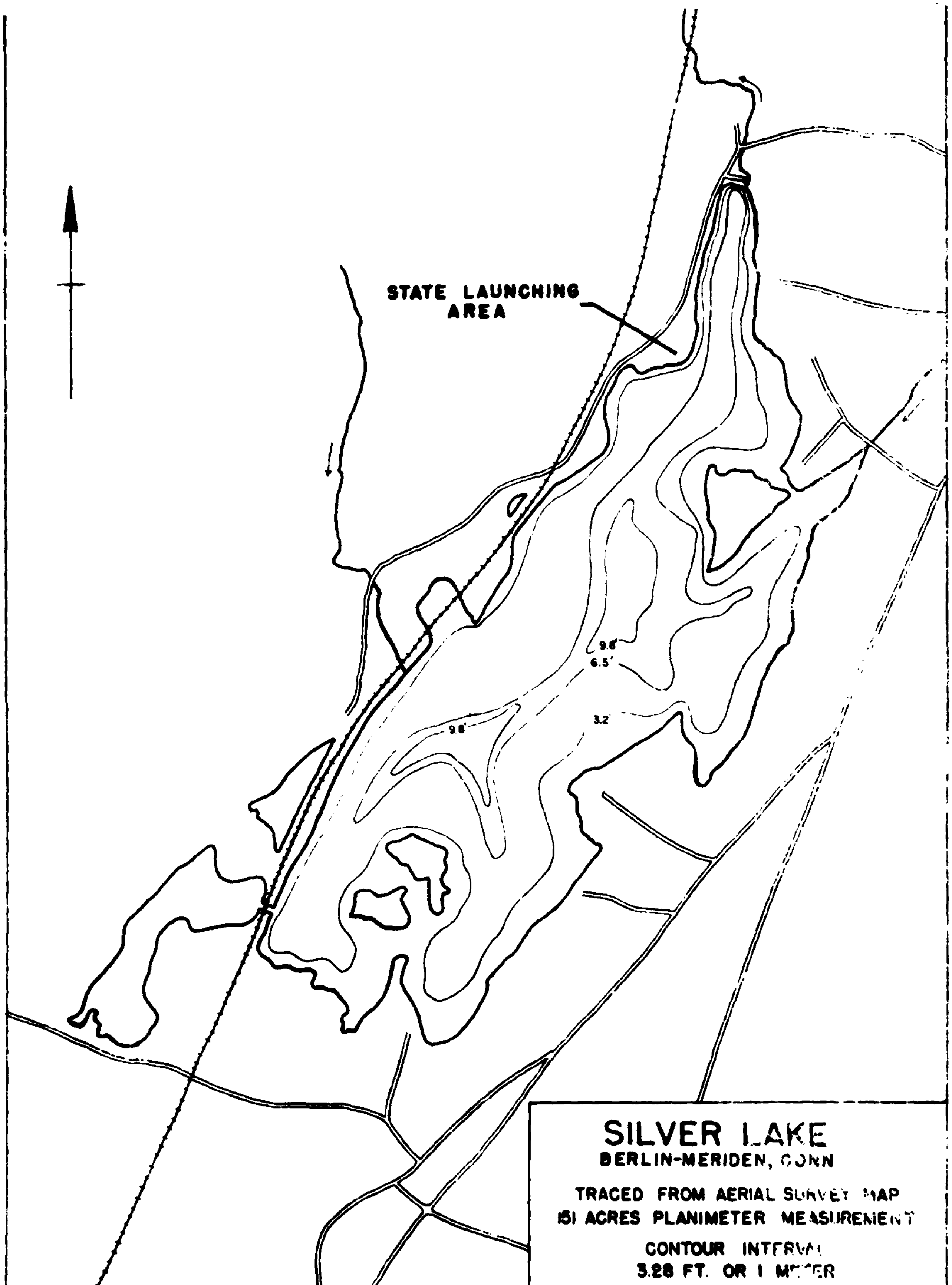
Downstream Conditions WOODS

Summary of File Data

1920?

Remarks 1.99 Sq.M. D.A.

Would Failure Cause Damage? YES Class B


STATE LAUNCHING AREA
9.8'
6.5'
9.8'
3.2'
SILVER LAKE
BERLIN-MERIDEN, CONN
TRACED FROM AERIAL SURVEY MAP
151 ACRES PLANIMETER MEASUREMENT
CONTOUR INTERVAL
3.28 FT. OR 1 METER
0 1 2 3
SCALE 1 = 600'

STATE OF CONNECTICUT
Department of Environmental Protection

LAKE AND POND SURVEY SERIES NO. 9

SILVER LAKE (Peat Works Pond)

Silver Lake located on the borders of Hartford and Middlesex Counties in the townships of Berlin and Meriden is a shallow, artificial impoundment fed by bottom springs and the headwaters of Belcher Brook. The lake is impounded by an earthen and masonry dam which is in good condition. The lake, formerly officially known as Peat Works Pond, has a surface area of 151 acres, a maximum depth of 12 feet and an average depth of 4.5 feet. The lake bottom is mostly of swampy ooze and organic detritus except in the shoreline shoal areas where it is of coarse gravel.

Silver Lake is extremely fertile and basic nutrients such as phosphates and nitrates are present at an unusually high level.

Because of the extremely high degree of fertility, both submerged and emergent vegetation are very dense during the spring. In the late spring or early summer, algal activity produces a dense bloom which reduces light penetration and results in the death and decay of most of the submerged vegetation.

Silver Lake is state-owned and there is a public boat launching area, including launching ramp and parking facilities at the northwestern end of the lake. Although there are a few cottages and homes on the eastern shore, shoreline development is rather low. The Penn-Central Railroad borders the lake on the west and the Berlin Turnpike (Route 15) parallels the lake about one-half mile to the east.

Silver Lake has been stocked with landlocked salmon, chain pickerel, yellow perch, black crappie, brown bullhead, golden shiners, sunfish, smallmouth bass, largemouth bass, northern pike and white catfish.

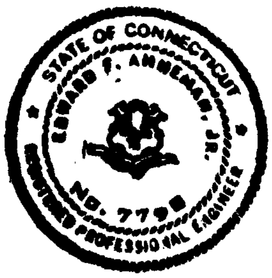
The lake was drained in 1961 while dam repairs were undertaken. After refilling the lake, it was restocked with largemouth bass, white catfish, yellow perch, chain pickerel and golden shiners.

Bluegill sunfish are extremely abundant and badly stunted from lack of food. White catfish are common in abundance and exhibit good growth. Although young-of-the-year largemouth bass are scarce, adult bass in the two to four pound class are common. Chain pickerel are scarce and exhibit a growth rate approximately equal to the state average for this species.

Until selective fish toxicants are available for use against common sunfish and bluegill sunfish, effective management of shallow fertile impoundments will remain an extremely difficult undertaking.

Revision 1971

Report and Recommendations
to
State of Connecticut
Department of Environmental Protection
for
Silver Lake Dam
Berlin, Connecticut



869-0136

ESTABLISHED 1887

S. E. MINOR & CO., INC.
CIVIL ENGINEERS
161 MASON STREET
GREENWICH, CONNECTICUT 06830

July 15, 1974

State of Connecticut
Department of Environmental Protection
State Office Building
Hartford, Connecticut 06115

Attention: Mr. Victor F. Galgowski
Superintendent of Dam Maintenance
Water and Related Resources

Re: Silver Lake Dam
Berlin, Connecticut

Dear Mr. Galgowski:

In accordance with your request, we have examined the subject dam in order to ascertain its structural soundness and stability. Prior to our visit to the site, we went to the Town Hall offices and attempted to obtain any structural drawings of the subject installation. We were advised that no plans were on file and that the Town Officials had no knowledge whatsoever of the construction of the dam.

Upon visiting the site, we examined the structure, which consists of an earth dam approximately ten feet wide on the top with a face slope of one foot on one foot and a back slope of one foot on three feet. There is approximately six feet of freeboard above a concrete inlet chamber that controls runoff.

During our visit to the site, we took some photos, which we have numbered on the reverse side for reference in this report. The dam generally runs in an east-west direction and is approximately 130 feet in length. The enclosed sketch of the dam and section indicate the location of the spillway inlet and outfall headwall.

During our visit, there was evidence of much duckweed and algae growth that was accumulating at the spillway, as evidenced in Photo No. 2. The outfall headwall as shown in Photo No. 3 indicates a further accumulation of said growth as it passes through the culvert. In Photo No. 4 there is evidence of rock and cobbles in the stream that tend to block the free flow which should be removed. If the stream were cleared of all such debris for a distance of approximately 25 feet downstream from the headwall, you would obtain an additional 15 feet drop in the elevation of the stream. In addition to this, I would recommend that the eight foot wide culvert be completely cleaned from the headwall through to the inlet chamber. There was no way of our telling how deep the culvert was as it is severely silted in.

It is our considered opinion that the dam is structurally sound and stable. There was no evidence of a dangerous high-water mark with the spillway in its present condition. Once cleaned, there certainly would be no danger whatsoever of overtopping. There was no evidence of fisher's leaks or boils anywhere on the dam.

It is our recommendation that the aforementioned maintenance steps be taken in the near future; and once completed, the dam should require only nominal maintenance.

Respectfully submitted,

S. E. MINOR & CO., INC.

Edw. F. Ahneman Jr.

Edward F. Ahneman, Jr.
Chief Engineer

EFA:lb

Cahn Engineers Inc.

MEMORANDUM

TO: Files

FROM: Cal Goldsmith

RE: Silver Lake Dam
Berlin, Connecticut
CE #27 595 KB

DATE: March 26, 1979

On Friday afternoon, March 23, 1979, I visited the site of Silver Lake Dam to quickly look over the dam and then to check out the downstream hazard potential. During this visit to the site, I noticed a large hole in the downstream face of this earth dam immediately upstream of the concrete headwall outlet structure. The hole was up to 6 feet across the top of the hole and tapered down to about 1 foot across at the bottom. Water could be seen flowing under the bottom of the hole from the outlet conduit into the headwall structure. Apparently the low level outlet conduit, a brick structure, had collapsed immediately upstream of the headwall for a distance of approximately a foot. This collapse exposed the water flowing in the conduit which in turn carried away the soil above it in the embankment slope. As the embankment was undermined, sloughing occurred resulting in the hole as well as slumping on the downstream slope continuously up to the crest of the dam.

I returned to the office and talked with Ted Stevens. Ted showed me pictures taken in late January, in which the downstream slope was intact. The sequence of events following:

- At about 5:10 p.m., I unsuccessfully tried to contact Perk Gould and Vic Galgowski from the Corps and the State, respectively.

- Called Mr. Vinal at home and informed him of the situation. He said that I should call the Corps emergency flood number. He also suggested I contact someone at the town of Berlin and referred me to Jim Carr, Ashwatha Narayana or Bob Kleffmann to get telephone numbers.

- Called Ashwatha Narayana and he referred me to Bob Kleffmann.

- Called Bob Kleffmann. He was hesitant to have me call anyone with the town as the dam was State owned. After discussion, Bob gave me Morgan Seeley's number and the name of a building inspector. I was unable to contact either, whereupon Bob agreed I should contact Mayor Ragazzi, which I did. I informed the Mayor of the problem and explained to him that the dam was State

owned and was a low to possibly significant hazard dam. I told him I had not been able to contact the Corps or the State, I felt someone in the Town of Berlin should be informed. He agreed, took my telephone number, and told me someone would contact me Saturday morning.

- After several calls to Mr. Caffrey at the Corps, I left a message for him at the Corps emergency flood number in Mass., asking him to contact Vic Galgowski at the State and ask Vic to have someone look at the dam Saturday morning.

- Called Mr. Vinal and left a message explaining who I called.

- At 7:30 a.m. Saturday morning, Morgan Seeley (Berlin Town Engineer) called me and said he would like to meet with me at the dam if possible. I told him I was available, but that I was going to try to get in touch with the State. He asked me to leave a message with Joe Paskiewicz, the Assistant Public Works Director, explaining what time the State would be on the dam.

- I tried to contact Vic Galgowski at the state, but there was no answer.

- I called Mr. Caffrey. He told me he got my message and had contacted Vic Galgowski at home Friday evening. Vic had said he would have someone at the dam Saturday morning.

- I informed Joe Paskiewicz of the situation.

- I called Mr. Vinal, and explained the situation. He said to contact Vic Galgowski if possible, which I wasn't able to do. Mr. Vinal had seen the dam on his way to work Saturday morning and agreed our actions were warranted.

- I stopped at the dam about 1:00 p.m. Saturday afternoon. I spoke with Mayor Ragazzi, Joe Paskiewicz and Rich Howard, the Assistant Town Engineer. I also spoke with Tony Cantelle of the State, who was supervising temporary repair efforts. He said Vic Galgowski had been at the dam around 9:30 that morning and left about 1/2 hour before I arrived. Temporary repair scheme:

  The area behind the headwall had been excavated exposing the back of the headwall and the brick conduit structure. Tony Cantelle was having the workmen retrieve large stones from the streambed and use them to bridge the gap between the head-wall and the brick structure. I left the site as

Cahn Engineers Inc.

MEMO

they were placing sand bags to fill the excavation. A town employee suggested filling the excavation with concrete. I suggested to Tony that the extra weight of the concrete could cause further collapse of the brick conduit. He agreed and cancelled the concrete.

- I called Vic Galgowski Monday morning. Vic agreed the dam was in need of immediate repair when he saw it Saturday. He suggested that the slump at the crest was old and the subsidence over the conduit noted a few years earlier, by S.E. Minor, was probably indicative that the undermining was at least that old. The severe undermining and slumping, he agreed was recent, however. Rich Howard quoted Vic as saying this was the closest to an emergency the state has had. Vic told me Monday that he was recommending the state proceed with immediate permanent repair to the dam. He wants to use emergency funds recently established, to repair the dam quickly. I recommended Vic have someone monitor the dam weekly. He asked for a letter stating this from us. Vic also expressed doubt that Silver Lake Dam was a low hazard dam. I had described the dam Friday in my message to Mr. Caffrey, as being a low-significant hazard dam. On Saturday, I examined further downstream and found two (2) houses which could be affected; therefore, I agreed with Vic that Silver Lake Dam was a significant hazard dam.

- Called Perk Gould Monday morning March 26, 1979 at the Corps and explained what happened. He agreed with the procedure we followed contacting people about the dam. He also agreed that the state should monitor the dam weekly and asked us to write a letter to him recommending weekly monitoring so that he could write a similar letter to the state.

Calvin R. Goldsmith

Calvin R. Goldsmith

/gjh

cc: Mr. E. P. Gould

Cahn Engineers Inc.

CONSULTING ENGINEERS-COMMUNITY DEVELOPMENT CONSULTANTS

May 14, 1979

Mr. Victor F. Galgowski
Water and Related Resources Unit
Department of Environmental Protection
State of Connecticut
State Office Building
Hartford, CT 06115

RE: Preliminary Hydraulic/Hydrologic Recommendations
Silver Lake Dam
Berlin, Connecticut
CE #27 595 KB

Dear Vic:

As requested in your telephone conversation with Mr. Goldsmith and approved by the Project Manager's Office of the Corps of Engineers, we are forwarding you a set of the hydraulic/hydrologic computations and preliminary recommendations for our Phase I investigation. The Phase I hydraulic/hydrologic computations are based on the "Probable Maximum Flood" (as estimated from Corps Guidelines) and are not intended to provide detailed analysis. The computations being forwarded should therefore be used with judgement and as a guide only, and should not be used as final design computations.

At this point in time, it appears that the hydraulic recommendations of our Phase I investigation will be as follows:

1. Hydrologists/hydralics engineers should perform a more sophisticated flood routing to refine the Test Flood figures. A study should be undertaken and recommendations made by a registered professional engineer to increase the spillway capacity based upon the refined Test Flood figures. The present drop inlet spillway configuration is poor and easily subject to blockage. The existing conduit for the low level outlet is partially collapsed on the downstream side and has caused servere erosion and sloughing of the downstream slope of the dam. Therefore, recommendations made to increase the spillway capacity should also address the problems of the poor spillway configuration and the condition of the culvert and downstream slope.

Reply to
20 Alexander Drive
PO Box 767
Wallingford Conn 06492
Phone (203) 269-8741

Reply to
7151 Frankford Avenue
Philadelphia Pennsylvania 19135
Phone (215) 333-3100

Reply to
315 Wyoming Ave
Forty Fort
Phone

Cahn Engineers Inc.

Mr. Victor F. Galgowski
Page 2
May 14, 1979

2. A registered, professional engineer qualified in dam design should make recommendations to construct an easily operable, properly sized low level outlet facility through the dam. During the course of the investigation, the engineer should also investigate the seepage and wet areas at the left and right ends of the dam to determine the significance of the seepage and make any needed recommendations to control or curb it.

Recommended remedial measures will include monitoring of seepage at the downstream toe of the dam, and replacement of riprap on the upstream slope to prevent erosion and sloughing. Riprap should be placed up to the crest of the dam, however, prior to placing the riprap, the minor sloughing of the upstream slope should be repaired and all trees and brush on the upstream slope should be removed.

If you have any questions, or if we can be of any further assistance, please feel free to call.

Very truly yours,

CAHN ENGINEERS, INC.

Peter M. Heynen

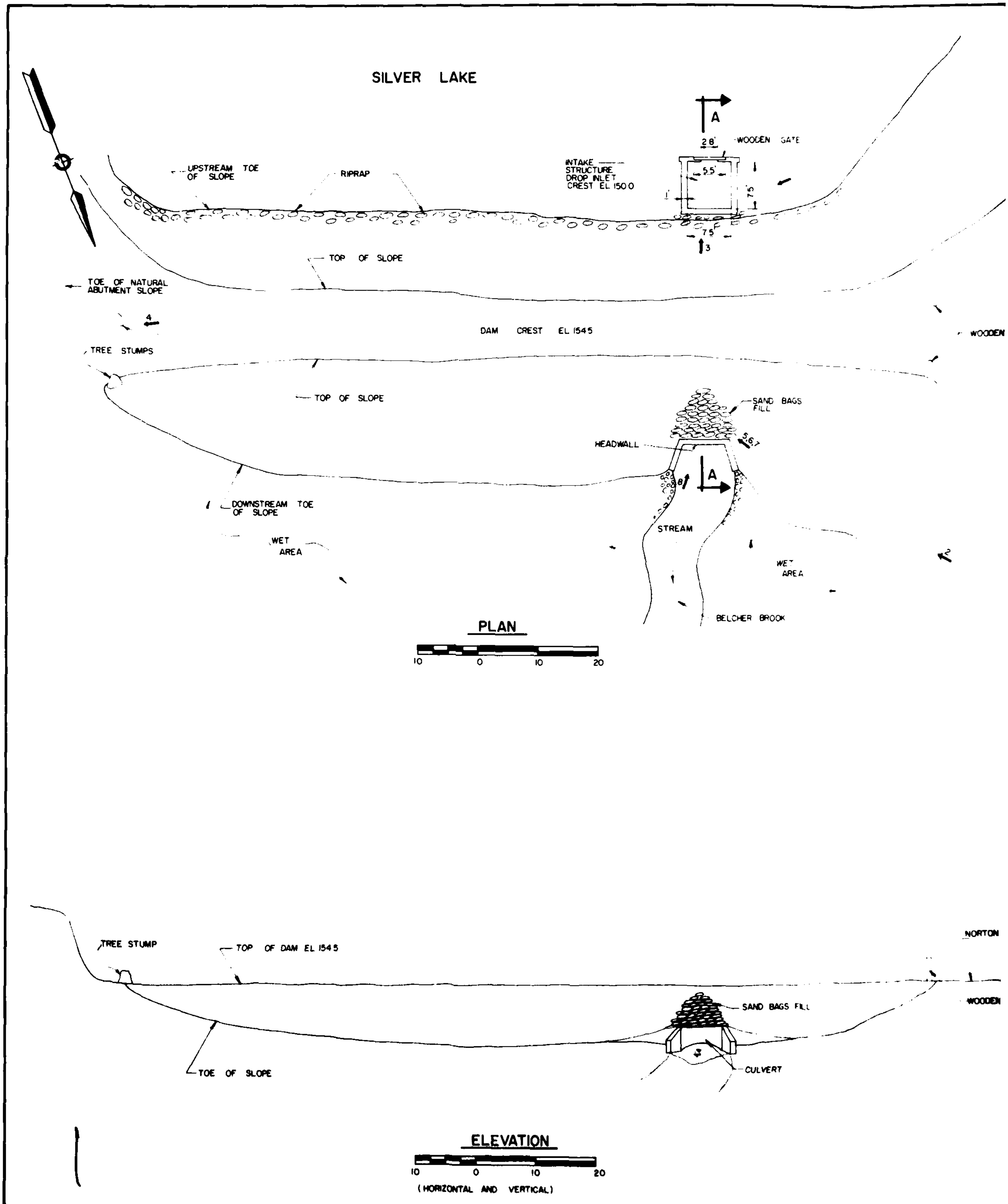
Peter M. Heynen, P.E.
Project Manager

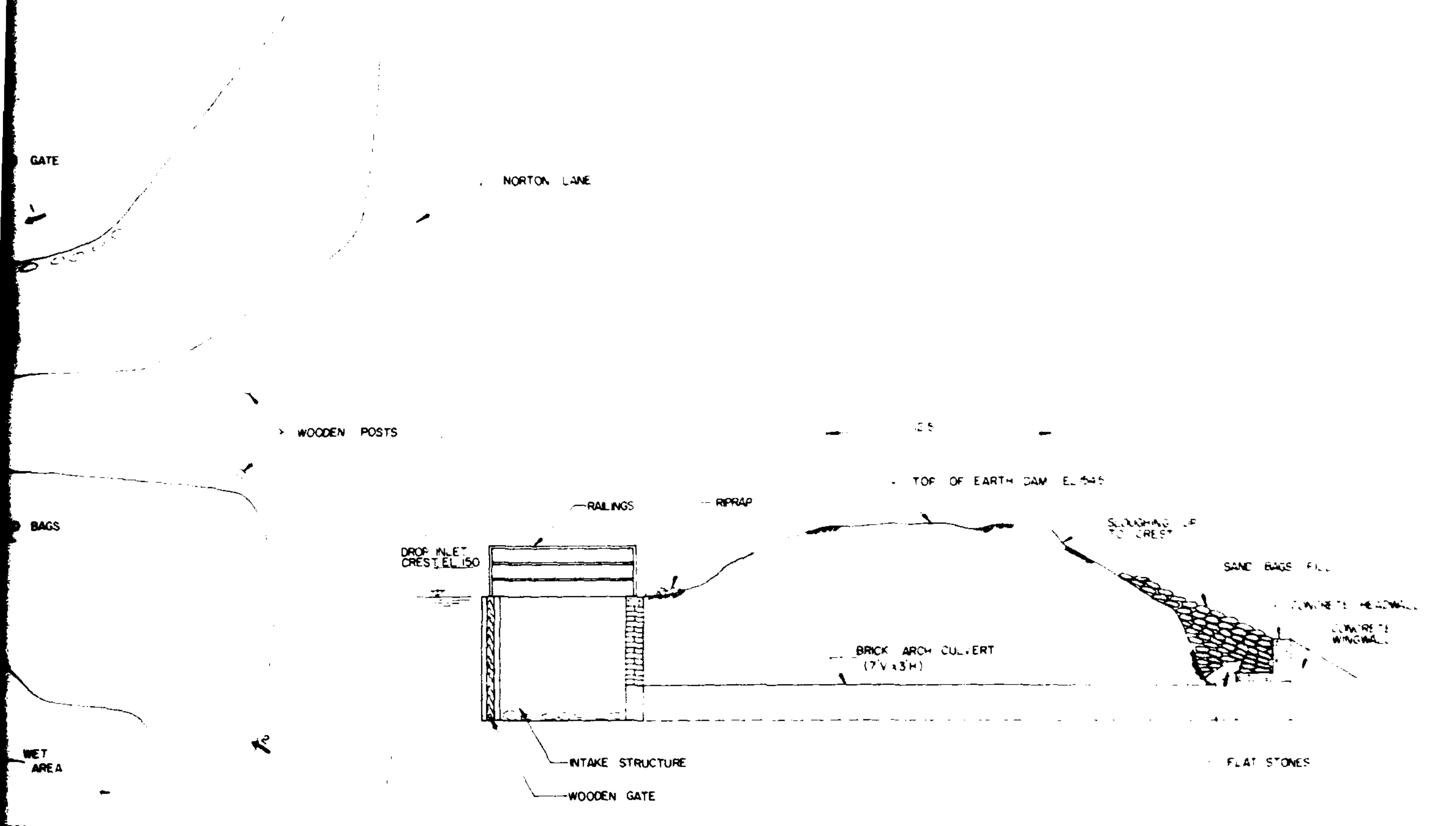
CRG/gjh

cc: Mr. E.P. Gould, NED, Corps of Engineer

APPENDIX C

DETAIL PHOTOGRAPHS


SILVER LAKE
A
2.8'
WOODEN GATE
INTAKE STRUCTURE DROP INLET CREST EL 1500
5.5'
7.5'
7.5'
UPSTREAM TOE OF SLOPE
RIPRAP
TOP OF SLOPE
TOE OF NATURAL ABUTMENT SLOPE
DAM CREST EL 1545
TREE STUMPS
WOODEN
TOP OF SLOPE
SAND BAGS FILL
HEADWALL
A
DOWNSTREAM TOE OF SLOPE
WET AREA
STREAM
WET AREA
BELCHER BROOK
PLAN
10 0 10 20
TREE STUMP
TOP OF DAM EL 1545
NORTON
WOODEN
SAND BAGS FILL
CULVERT
TOE OF SLOPE
ELEVATION
10 0 10 20
(HORIZONTAL AND VERTICAL)



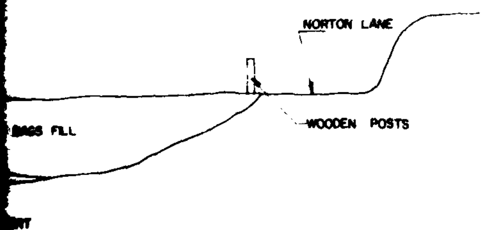
SECTION A-A

5 0 5 10

(CROSS-SECTION OF OUTLET WORKS SHOWING TEMPORARY REPAIRS)

NOTES

1. THIS PLAN WAS COMPILED FROM ROUGH FIELD SURVEY ONLY. NO PLANS FOR THE DAM WERE AVAILABLE. DIMENSIONS SHOWN ARE APPROXIMATE AND NOT ALL STRUCTURAL AND/OR TOPOGRAPHIC FEATURES ARE IDENTIFIED.
2. ELEVATIONS SHOWN ARE RELATIVE TO AN ASSUMED INTAKE STRUCTURE CREST ELEVATION TAKEN TO BE THE SAME AS THE WATER SURFACE ELEVATION OF SILVER LAKE SHOWN ON THE MERIDEN U.S.G.S. QUADRANGLE MAP.
3. TEMPORARY REPAIRS WERE PERFORMED BY THE STATE OF CONNECTICUT APPROXIMATELY AS SHOWN ON MARCH 24, 1979 TO STABILIZE THE DOWNSTREAM SLOPE IN THE VICINITY OF THE OUTLET WORKS.
4. ←2 PICTURE NUMBER AND DIRECTION



CAHN ENGINEERS INC WALLINGFORD, CONNECTICUT ENGINEER	U S ARMY ENGINEER DIV NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

PHOTOGRAPH LOCATION PLAN

SILVER LAKE DAM

2

BELCHER BROOK — BERLIN, CONNECTICUT

DRAWN BY	CHECKED BY	APPROVED BY	SCALE AS NOTED	
N.N.	CRG	[illegible]	DATE MAY 1979	PLATE - 2A

PHOTO 1 - Drop inlet and upstream slope of dam. Note unevenly dumped trap rock riprap and saplings to right of inlet.

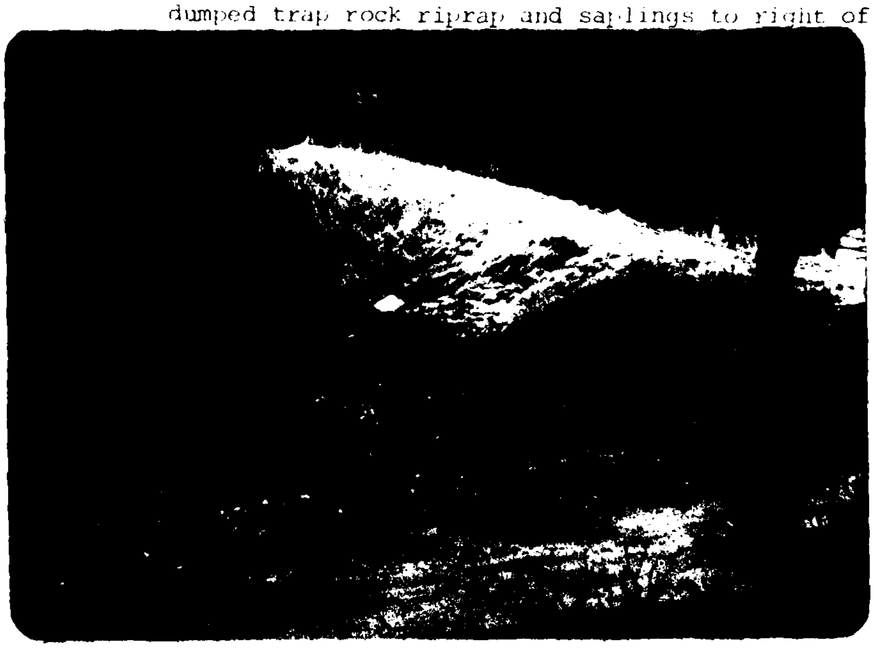


PHOTO 2 - View of crest and downstream slope from left abutment. Note heavy vegetation on downstream slope.

US ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS	NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	SILVER LAKE DAM BELCHER BROOK BERLIN, CONNECTICUT
CAHN ENGINEERS INC. WALLINGFORD, CONN. ENGINEER		CE # 27 595 KB DATE June '79 PAGE C-1

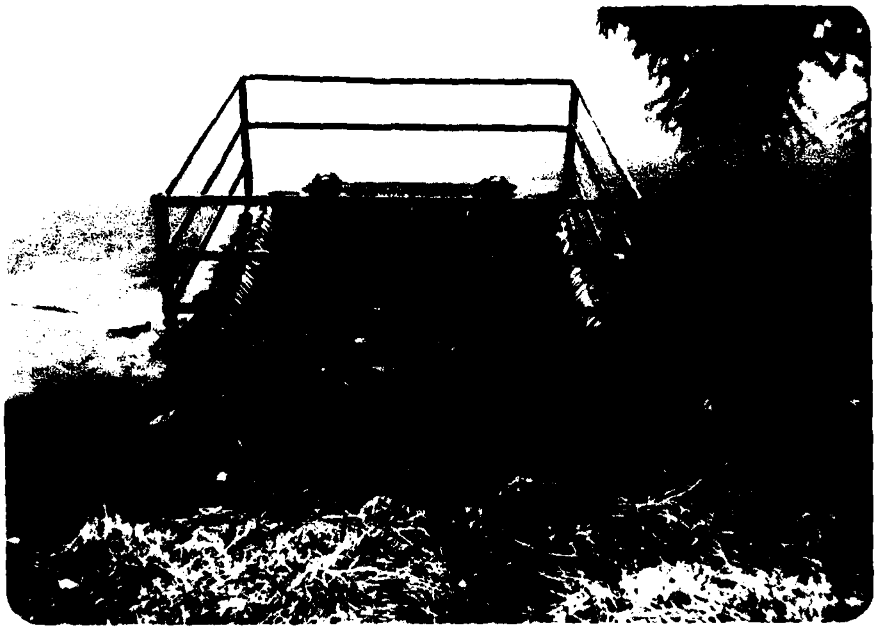


PHOTO 3 - Drop inlet. Note gate on far side of inlet and log floating toward inlet crest.

PHOTO 4 - View of right abutment showing 2 large tree stumps on dam crest.

US ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS	NATIONAL PROGRAM OF	SILVER LAKE DAM
	INSPECTION OF	BELCHER BROOK
CAHN ENGINEERS INC. WALLINGFORD, CONN. ENGINEER	NON-FED. DAMS	BERLIN, CONNECTICUT
		CE # 27 595 KB
		DATE June '79 PAGE C-2

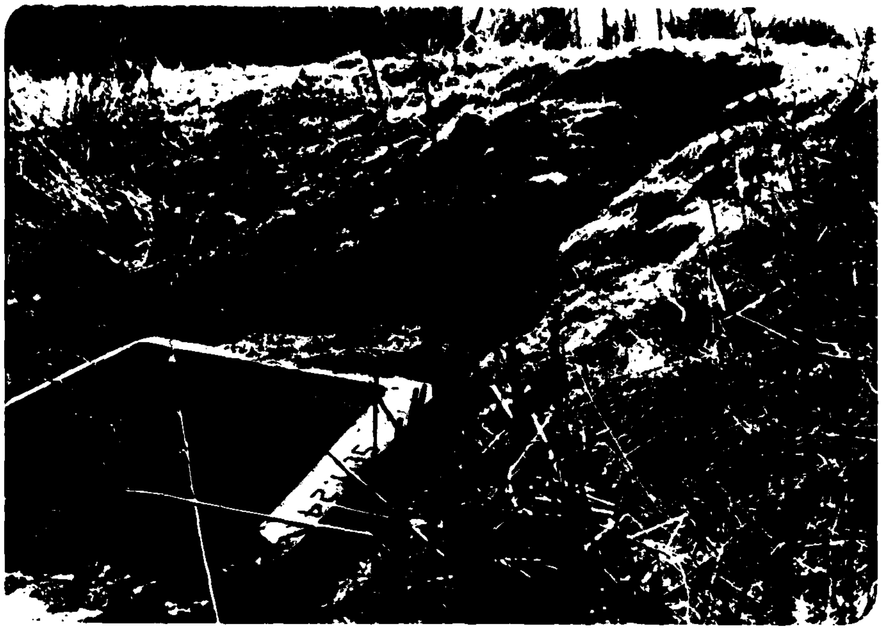


PHOTO 5 - View of downstream slope failure and sloughing to crest due to partial collapse of conduit. Note date "Sept. 24, '42" on concrete headwall.

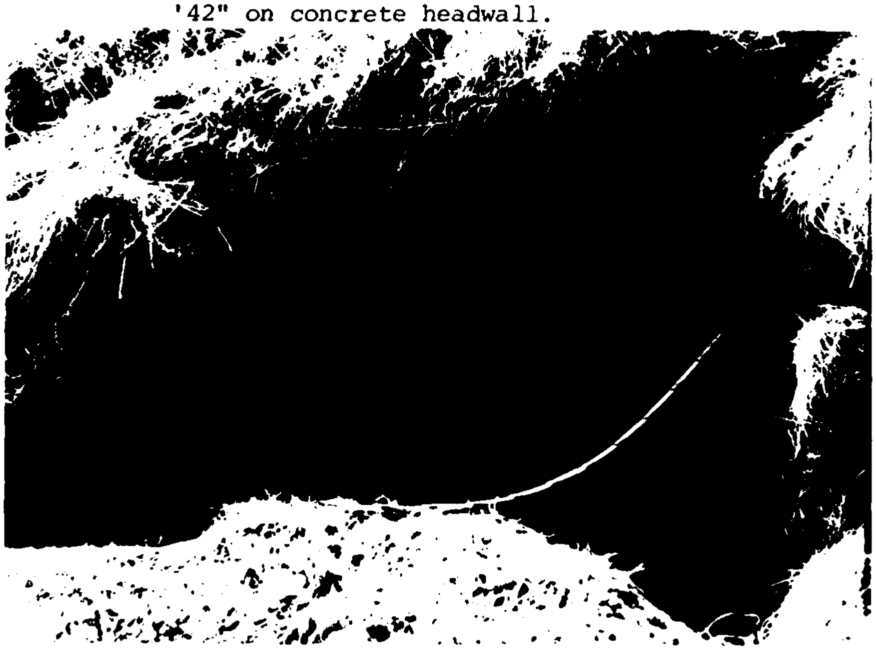


PHOTO 6 - Close-up of hole in dam above conduit. Note six foot rule across hole. Photos 5 and 6 taken March 23, 1979, repairs undertaken the following day.

US ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS	NATIONAL PROGRAM OF	SILVER LAKE DAM BELCHER BROOK BERLIN, CONNECTICUT
CAHN ENGINEERS INC. WALLINGFORD, CONN. ENGINEER	INSPECTION OF NON-FED. DAMS	CE# 27 595 KB DATE June '79 PAGE C-3

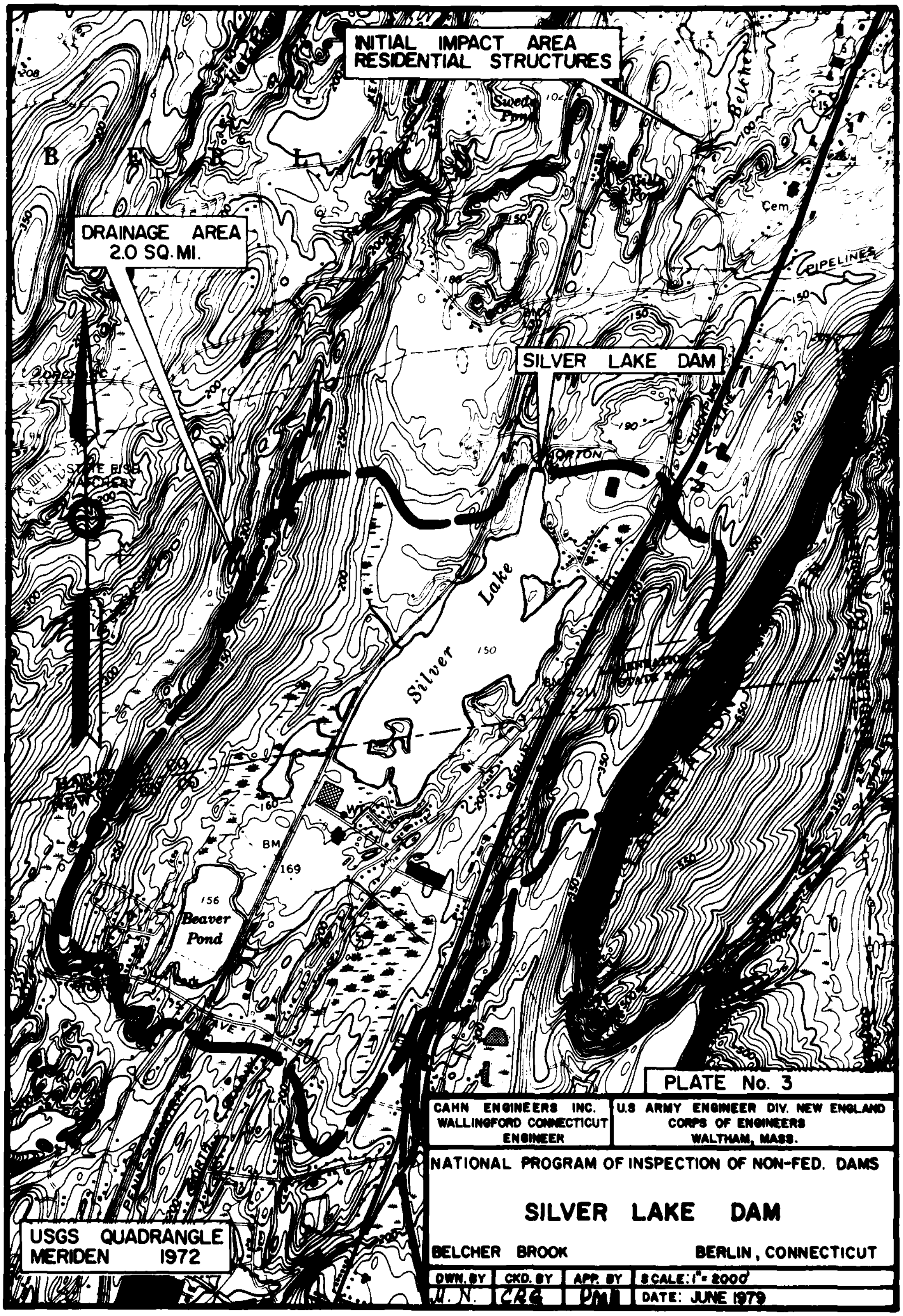
PHOTO 7 - Temporarily repaired downstream slope.

PHOTO 8 - Concrete headwall at downstream toe of dam. Note undermining of wingwall and siltation of conduit.

US ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS	NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	SILVER LAKE DAM BELCHER BROOK BERLIN, CONNECTICUT CE# 27 595 KB
CAHN ENGINEERS INC. WALLINGFORD, CONN. ENGINEER		DATE June '79 PAGE C-4

APPENDIX D

HYDRAULICS/HYDROLOGIC COMPUTATIONS



INITIAL IMPACT AREA
RESIDENTIAL STRUCTURES
DRAINAGE AREA
2.0 SQ. MI.
SILVER LAKE DAM
Silver Lake
Beaver Pond
PIPELINES
Cem
USGS QUADRANGLE
MERIDEN 1972
PLATE No. 3
CAHN ENGINEERS INC.
WALLINGFORD CONNECTICUT
ENGINEER
U.S ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS
SILVER LAKE DAM
BELCHER BROOK
BERLIN, CONNECTICUT
DWN. BY
CKD. BY
APP. BY
SCALE: 1" = 2000'
DATE: JUNE 1979

Cahn Engineers Inc. Consulting Engineers

Project INSPECTION OF NON-FEDERAL DAMS IN NEW ENGLAND Sheet 1 of 15
Computed By HW Checked By TS Date 5/1/79
Field Book Ref. Other Refs. CE #27-595-KB Revisions

HYDROLOGIC / HYDRAULIC INSPECTION

SILVER LAKE DAM, BERLIN, CT.

I) PERFORMANCE AT TEST FLOOD CONDITIONS:

1) MAXIMUM PROBABLE FLOOD

a) WATERSHED CLASSIFIED AS "ROLLING" TO "FLAT"

b) WATERSHED AREA: $D.A. \cong 2.0^{sq\,mi}$

NOTE: USGS, HARTFORD OFFICE: $DA = 1.99^{sq\,mi}$; C.E. MEASURE ON MERIDEN, CT QUADRANGLE SHEET 1:24000: $DA = 1.97^{sq\,mi}$

c) FROM NED-ACE "PRELIMINARY GUIDANCE FOR ESTIMATING MAX. PROBABLE DISCHARGES" GUIDE CURVE FOR PMF - PEAK FLOW RATES EXTRAPOLATION TO DA'S $\leq 2.0^{sq\,mi}$

$PMF \cong 1700^{cfs}/sq\,mi$

d) PEAK INFLOW: $PMF \cong 1700 \times 2 \cong 3400^{cfs}$

2) SPILLWAY DESIGN FLOOD (SDF)

a) CLASSIFICATION OF DAM ACCORDING TO NED-ACE RECOMMENDED GUIDELINES:

i) SIZE: STORAGE (MAX) $\cong 1480^{ac\,ft}$ $(1000 < S < 50000^{ac\,ft})$
HEIGHT $\cong 15'$ $(6 < H < 25^{ft})$

STORAGE FROM CT. DEPT. OF ENVIRONMENTAL PROTECTION BATHYMETRIC MAP OF SILVER LAKE - SCALE: $1^{cm} \cong 300'$ ($1'' = 762'$) AND $1^{mt.}$ CONTOUR INTERVAL, CE MEASURE STORAGE $S \cong 670^{ac\,ft}$ TO FLOW LINE (ASSUMED

Cahn Engineers Inc. Consulting Engineers

Project NON-FEDERAL DAMS INSPECTION Sheet 2 of 15
Computed By HK Checked By TC Date 5/1/79
Field Book Ref. Other Refs. CE#27-595-KB Revisions

SILVER LAKE DAM

2,a,i-Cont'd) SIZE CLASSIFICATION

STORAGE (Cont'd): TO BE AT ELEV.* 150' MSL). LAKE AREA AT FLOW LINE (SAME REFERENCES) $A_{150} \cong 151$ AC.; AREA AT CONTOUR 160' MSL (CE MEASURE) $A_{160} = 282$ AC; $\Delta A = 131$ AC.; HEIGHT OF DAM ABOVE OUTLET $H_f = 4.5'$ ∴ AVE. LAKE AREA TO TOP OF DAM $A_{AVE} \cong 180$ AC.
∴ MAX. STORAGE TO TOP OF DAM: $S_{MAX} \cong 670 + 4.5 \times 180 \cong$ 1480 AC-FT

HEIGHT ESTIMATED FROM C.E. SURVEY & FIELD OBSERVATIONS.

ii) HAZARD POTENTIAL: TWO HOUSES, (±) 1 MI D/S FROM THE DAM, BY GILLS POND ALONG BELCHER BROOK, ARE PARTICULARLY LOW (3' TO 4' ABOVE THE STREAMBED). LOW HOUSES ALONG THE RIGHT SHORE OF SILVER LAKE MAY BE SUBJECT TO FLOODING AT HIGH LAKE WATER LEVELS.

iii) CLASSIFICATION:

SIZE: INTERMEDIATE
HAZARD: SIGNIFICANT

b) SDF = 1/2 PMF = 1700 CFS   PMF = 3400 CFS

3) SURCHARGE AT PEAK INFLOW:

a) PEAK INFLOW: $Q_p = 1700$ CFS $Q_{p}' = PMF = 3400$ CFS

*NOTE: OUTLET STRUCTURE CREST ELEV. AND FLOW LINE ASSUMED TO BE ELEV. 150' MSL AS SHOWN ON THE USGS MERIDEN, CT. QUADRANGLE MAP, PHOTO-REVISED 1972.

Cahn Engineers Inc. Consulting Engineers

Project NON-FEDERAL DAMS INSPECTION Sheet 3 of 15
Computed By [signature] Checked By TS Date 5/1/79
Field Book Ref. Other Refs CE # 27-541-KS Revisions

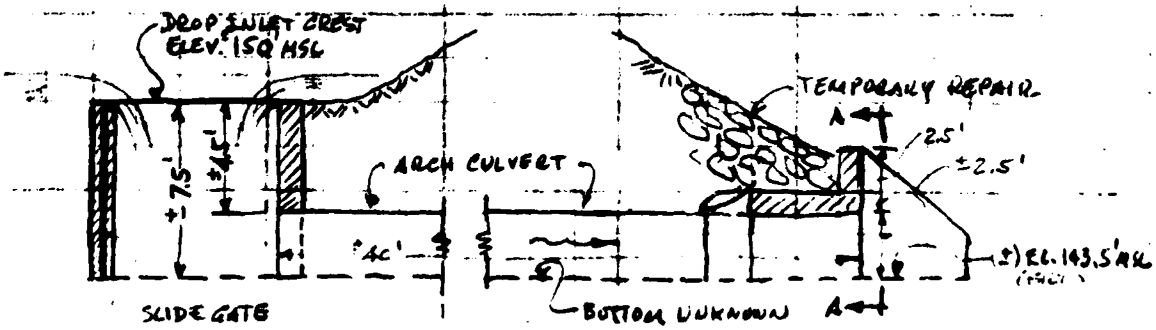
SILVER LAKE DAM

3-Cont'd) SURCHARGE AT PEAK INFLOWS

b) SPILLWAY (OUTFLOW) RATING CURVE

i) SPILLWAY

THE OUTLET STRUCTURE OF SILVER LAKE DAM IS A (±) 9.5' × 9.5' SQUARE SHAPED DROP INLET SPILLWAY. THE CREST (ELEV. (±) 150' MSL) IS (±) 1' BROAD. THE BOX (SHAFT) IS (±) 7.5' TO 8' DEEP AND DISCHARGES THRU AN ARCH-CULVERT-TYPE CONDUIT (±) 40' LONG. THE CHORD AT THE BASE OF THE ARCH, AT THE OULET, IS (±) 7' AND THE RISE (±) 2.5'. AT LEAST AT THE OUTLET, THE CULVERT IS SILTED TO THE CHORD OF THE ARCH AND THEREFORE, THE ACTUAL TYPE, SHAPE AND DEPTH OF THE INVERT OF THE CULVERT (CONDUIT) IS UNKNOWN. HOWEVER, FROM ROUGH MEASUREMENTS AT THE INLET, UNDER OVERFLOWING CONDITIONS, IT IS ESTIMATED THAT THE MAXIMUM HEIGHT OF THE CONDUIT IS (±) 3'. THE U/S (LAKE) FACE OF THE INLET BOX INCLUDES A WOODEN SLIDE GATE (±) 2'-10" WIDE AND, PRESUMABLY, (±) AS HIGH AS THE SHAFT. i.e, (±) 7.'



DROP INLET SPILLWAY APPROXIMATE LONGITUDINAL CROSS SECTION

(SEE SKETCH OF INLET PLAN AND VIEW A-A NEXT PAGE (p.4))

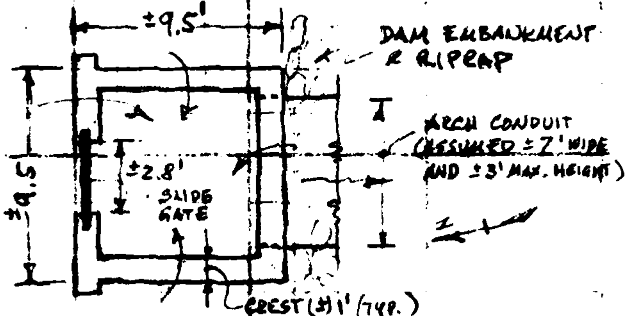
Cahn Engineers Inc. **Consulting Engineers**

Project NON-FEDERAL DAMS INSPECTION — Sheet 4 of 15
Computed By [signature] — Checked By TS — Date 5/2/79
Field Book Ref. — Other Refs. CE #27-595-KB — Revisions

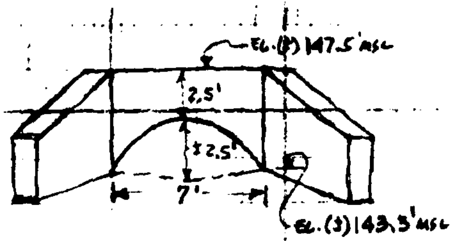
SILVER LAKE DAM

3.b(i-Cont'd) OUTFLOW RATING CURVE - SPILLWAY

THE HEIGHT BETWEEN THE DROP INLET CREST (ELEV. (±) 150' MSL) AND THE TOP OF THE DAM (ELEV. (±) 154.5' MSL) IS H ≈ 4.5'. A 3' HIGH PIPE RAILING SURROUNDS THE INLET.



DROP INLET SPILLWAY PLAN



CONDUIT OUTLET FRONT VIEW (A-A)

(SEE SPILLWAY'S CROSS SECTION ON PREVIOUS PAGE (P.3))

NOTE: DATA FROM C.E. FIELD SURVEY (4/17/79) AND OBSERVATIONS.

THEREFORE, ASSUME WEIR C = 3.2 OVER THE DROP INLET CREST.

IT IS ASSUMED THAT THIS COEFFICIENT ACCOUNTS FOR FACTORS AFFECTING THE FLOW LIKE INTERFERENCE BY THE RAILING, PROXIMITY OF THE DAM AND HIGH GROUND AGAINST THE SIDES AND BACK OF THE INLET.

USING THE CREST ELEVATION OF THE DROP INLET AS DATUM, THE SPILLWAY DISCHARGE UNSUBMERGED IS APPROXIMATED BY:

$$Q_S \approx 110 H^{3/2} \quad \therefore \quad H = \left(\frac{Q_S}{110}\right)^{2/3} \quad (L = (9.5-1)\times 4 = 34')$$

ASSUMING THE CONDUIT FLOWING FULL AND TAILWATER APPROX. TO THE CROWN OF THE CONDUIT; $K_e \approx 0.7$ (ROUGH SQUARE ENTRANCE WITH FLOW INTERFERENCE AND HIGH TURBULENCE BECAUSE OF THE FALLING NAPPE).

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Project NON-FEDERAL DAMS INSPECTION Sheet 5 of 15

Computed By HCU Checked By 7 Date 5/2/79

Field Book Ref. Other Refs. CE #31 571-KB Revisions

SILVER LAKE DAM

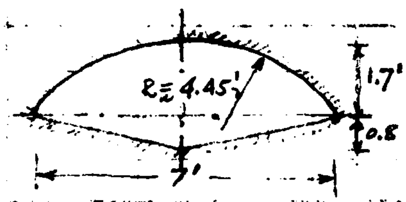
3,b,c-Cont'd) OUTFLOW RATING CURVE - SPILLWAY

$n \approx 0.018$ (FULL CONDUIT CONVEYANCE $^*K_{18} \approx 745$); THE HEADWATER ELEVATION REFERED TO THE SAME DATUM (CREST OF SPWY) CAN BE APPROXIMATED BY:

$$H_C = H - H_E = \left(\frac{1+K_e}{2gA^2} + \frac{L}{K^2}\right)Q^2 - H_E$$

WHERE $H_E \approx 150 - (147.5 - 2.5) = 5'$ IS THE DIFFERENCE IN ELEVATIONS BETWEEN THE SPILLWAY CREST AND THE ASSUMED TAILWATER.

THE FULL CONDUIT GEOMETRIC PARAMETERS (SEE SKETCH) FOR COMPUTATION OF THE CONVEYANCE ARE AS FOLLOWS:



$A \approx 11.1$ SQ FT $P = 15.2'$ $\therefore$ $^*K_{18} \approx 745$

THEREFORE, FOR THE CONDUIT ($L \approx 40'$) THE RATING CURVE CAN BE APPROXIMATED BY THE RELATIONSHIP:

$$H_C \approx 2.86 \times 10^{-4} Q^2 - 5$$

H_C COULD BE POSITIVE OR NEGATIVE DEPENDING ON WHETHER THE SPILLWAY CREST IS SUBMERGED OR NOT BY THE CONDUIT HEADWATER. TAILWATER CONDITIONS CAN BE CHANGED BY CHANGING H_E.

FROM THE ABOVE, FOR TAILWATER AT THE CROWN OF THE CULVERT OUTLET, THE DROP INLET SPILLWAY WILL BECOME SUBMERGED AT FLOWS APPROX. $Q \gtrapprox 132$ CFS. IT SHOULD BE NOTED THAT FOR HIGHER TAILWATERS, THE CONDUIT CONTROL WILL BEGIN AT SMALLER DISCHARGES. FOR INSTANCE, IF TW. IS ASSUMED 1' ABOVE THE OUTLET

D-5

SILVER LAKE DAM

3.6.c - Cont'd) OUTFLOW RATING CURVE - SPILLWAY

THEN THE CONDUIT CONTROL WILL START AT (±) $Q \cong 118^{cfs}$

THEREFORE, FOR TW AT THE CROWN OF THE CONDUIT OUTLET, THE CONDUIT CONTROL WILL START AT AN OUTFLOW OF (±) 118 CFS CORRESPONDING TO A SURCHARGE OF:

$$H \cong \left(\frac{132}{110}\right)^{2/3} \cong 1.1'$$

SPILLWAY CAPACITY WITHIN THE SUBMERGED RANGE CAN BE APPROXIMATED BY THE VILLEMONTE'S EQUATION:

$$\frac{Q}{Q_1} = \left[1 - \left(\frac{H_2}{H_1}\right)^{1.5}\right]^{0.385} \quad \text{OR,} \quad \frac{Q_2}{Q_1} + \left(\frac{Q}{Q_1}\right)^{2.60} = 1$$

WHERE Q_1 AND Q_2 ARE FREE FLOW DISCHARGES UNDER THE HEADS H_1 AND H_2 (U/S AND D/S FROM THE SPILLWAY) AND Q IS THE ACTUAL FOR THE SUBMERGED FLOW CONDITIONS.

THE SOLUTION OF THE ABOVE EQUATION GIVES A FLOW $Q \approx 182^{cfs}$ FOR A HEAD $H_1 = 4.5'$ (TO TOP OF DAM) AND THE SPILLWAY WILL BE FOR ALL PRACTICAL PURPOSES, TOTALLY SUBMERGED ($H_2 \cong 4.47'$); i.e. THE SPILLWAY TRANSITIONS TO A "FULL PIPE" FLOW CONDITION WITH ENTRANCE AT THE BOX INLET AND $H_2 \cong H_1$. IT IS TO BE NOTED THAT FOR THESE "FULL PIPE" CONDITIONS THE CONDUIT FORMULA ON PAGE 5 WILL REPRESENT THE TOTAL HEAD/DISCHARGE RELATIONSHIP IF THE VELOCITY HEAD AND FRICTION LOSSES AT THE INLET BOX ARE ADDED TO THE CONDUIT LOSSES. THESE LOSSES ARE NEGLIGEABLE ($\approx 8.34 \times 10^{-6} Q^2$) AND THEREFORE THE FORMULA ON PAGE 5:

$$H_1 \cong H_2 \cong 2.86 \times 10^{-4} Q^2 - 5$$

Cahn Engineers Inc. **Consulting Engineers**

Project NON-FEDERAL DAMS INSPECTION Sheet 7 of 15
Computed By HM Checked By TS Date 5/3/79
Field Book Ref. Other Refs. CE #27-59-KB Revisions

SILVER LAKE DAM

3. b. i. - Cont'd) OUTFLOW RATING CURVE - SPILLWAY

CAN BE USED TO REPRESENT THE DROP INLET "FULL PIPE" FLOW CONDITION.

ii) EXTENSION OF THE RATING CURVE FOR SURCHARGE HEADS ABOVE TOP OF DAM.

THE DAM IS AN EARTHFILL EMBANKMENT, IN THE AVERAGE (±) 12' WIDE AT THE TOP (± ELEV. 159.5' MSL). THE TOTAL LENGTH AT THIS ELEVATION, INCLUDING FLAT PORTIONS OF THE TERRAIN AT THE SIDES, IS (±) $L_D = 155'$ (C.E. FIELD SURVEY).

AT BOTH SIDES, BEYOND THE DAM AND OTHER GROUND AT ELEV. 154.5', THE TERRAIN RISES SHARPLY AT (±) 1^H TO 2^V SLOPE.

ASSUME C = 2.8 FOR THE EARTH EMBANKMENT AND SIDES OVERFLOW.

ASSUMING, ALSO, AN EQUIVALENT LENGTH FOR THE SLOPING TERRAIN AT BOTH SIDES OF THE DAM (STEEP SIDES):

$$L'_R = L'_D = \frac{1}{2}\left(\frac{1}{2}\right)(H-4.5) \quad \therefore \quad L' = L'_R + L'_D = 0.5(H-4.5)$$

THE TOTAL OVERFLOW MAY BE APPROXIMATED BY THE FORMULA:

$$Q = Q_S + Q_D + Q_{S,R} = Q_S + \underbrace{2.8 \times 155 (H-4.5)^{3/2}}_{(\approx 430)} + \underbrace{2.8 \times .5 (H-4.5)^{5/2}}_{(1.4)}$$

WHERE Q_S IS THE DROP INLET SPWY FLOW GIVEN BY THE APPLICABLE FORMULA DEPENDING ON THE SURCHARGE HEAD AND DEGREE OF SUBMERGENCE ($H \lesssim 4.5$) OR BY THE "FULL PIPE" FLOW CONDITION FORMULA ($H \gtrsim 4.5$):

$$H = 2.86 \times 10^{-4} Q_S^2 - 5 \quad \therefore \quad Q_S = 59(H+5)^{1/2}$$ (SEE PREVIOUS PAGE 6)

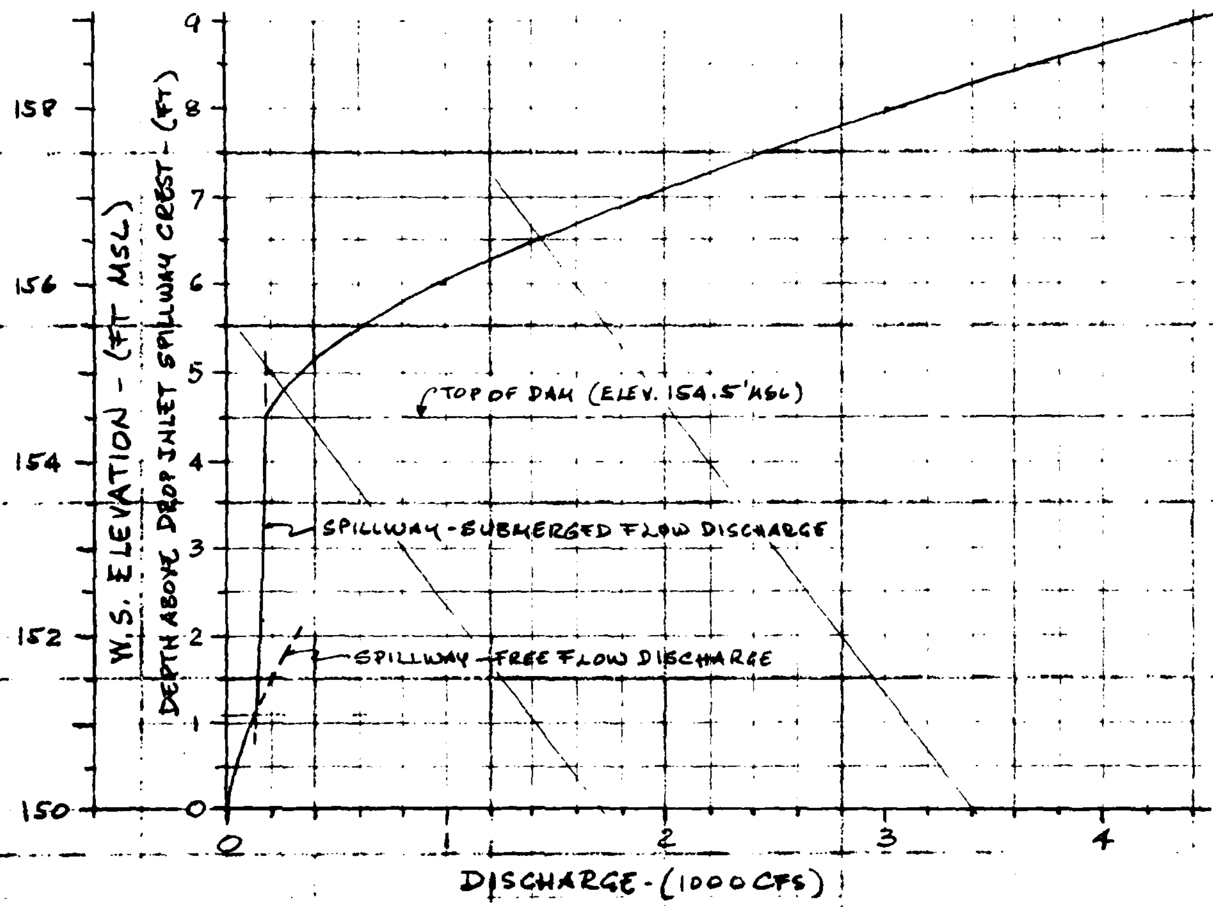
D-7

Cahn Engineers Inc. **Consulting Engineers**

Project NON-FEDERAL DAMS INSPECTION Sheet 8 of 15
Computed By HLL Checked By TS Date 5/3/79
Field Book Ref. Other Refs. CE #27-595-KB Revisions

SILVER LAKE DAM

3-Cont'd) OUTFLOW RATING CURVE



C) SPILLWAY CAPACITY TO TOP OF DAM

$H = 4.5' \therefore Q_S \approx 180$ CFS ($\pm$)11% OF Q_{P1}, ($\pm$)5.3% OF $Q_{P/2}$)

NOTE: THE SPILLWAY AT THIS FLOW WILL OPERATE UNDER FULL SUBMERGENCE.

Cahn Engineers Inc. Consulting Engineers

Project NON-FEDERAL DAMS INSPECTION Sheet 9 of 15
Computed By HAY Checked By TS Date 5/3/79
Field Book Ref Other Refs. CE # 27-545-KB Revisions

SILVER LAKE DAM

3-Cont'd) SURCHARGE AT PEAK INFLOW

d) SURCHARGE HEIGHT TO PASS Q_{P_1}

i) @ Q_{P_1} = 1/2 PMF = 1700 cfs $H_1 \approx 6.8'$

ii) @ Q'_{P_1} = PMF = 3400 cfs $H'_1 \approx 8.3'$

4) EFFECT OF SURCHARGE ON MAX. PROBABLE DISCHARGES (OUTFLOW)

a) RESERVOIR (LAKE) AREA @ FLOW LINE: $A_0 = 151^{AC}$

NOTE: SEE "STORAGE" ON P. 2 OF THESE COMPUTATIONS FOR DISCUSSION ON LAKE AREAS.

∴ ASSUME AVE LAKE AREA WITHIN EXPECTED SURCHARGE, $A \approx 180^{AC}$

b) ASSUME NORMAL POOL LEVEL AT SPILLWAY CREST (ELEV. 150' MSL)

c) WATERSHED AREA: D.A. ≈ 2.0 sq mi (SEE P. 1 OF THESE COMPS)

d) DISCHARGE (Q_{P_2}) AT VARIOUS HYPOTHETICAL SURCHARGE DEPTHS

$H = 5'$ $V = 180 \times 5 = 900$ AC-FT ∴ $S = \frac{900}{2 \times 53.3} = 8.44''$

$H = 3'$ $V = 540$ AC-FT ∴ $S = 5.07''$

∴ FROM APPROXIMATE STORAGE ROUTING NED-ACE GUIDELINES (19" MAX. PROBABLE R.O. IN NEW ENGLAND)

$$Q_{P_2} = Q_{P_1}\left(1 - \frac{S}{9.5}\right) \text{ AND FOR PMF: } Q'_{P_2} = Q'_{P_1}\left(1 - \frac{S}{19}\right)$$

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Project NON-FEDERAL DAMS INSPECTION Sheet 10 of 15

Computed By HCL Checked By TS Date 5/4/79

Field Book Ref. Other Refs. CE # 27-595-KB Revisions

SILVER LAKE DAM

4, d - Cont'd) DISCHARGE (Q_{P_2}) AT VARIOUS HYPOTHETICAL SURCHARGE DEPTHS

∴ FOR THE GIVEN HYPOTHETICAL SURCHARGES:

$H = 5'$ $Q_{P_2} \doteq 189^{cfs}$ $Q'_{P_2} \doteq 1890^{cfs}$

$H = 3'$ $Q_{P_2} \doteq 794^{cfs}$ $Q'_{P_2} \doteq 2490^{cfs}$

AND FOR $H = 0$; $Q_{P_2} = 1700^{cfs}$, $Q'_{P_2} \doteq 3400^{cfs}$

e) PEAK OUTFLOW (Q_{P_3})

USING NED-ACE GUIDELINES "SURCHARGE STORAGE ROUTING" ALTERNATE METHOD (SEE p. 8 OF THESE COMPUTATIONS):

$Q_{P_3} \doteq 250^{cfs}$ $H \doteq 4.8'$ FOR $Q_{P_1} = ½ PMF$

$Q'_{P_3} \doteq 1430^{cfs}$ $H \doteq 6.5'$ FOR $Q'_{P_1} = PMF$

f) SPILLWAY CAPACITY RATIO TO OUTFLOW:

SPILLWAY CAPACITY TO TOP OF DAM: $Q_S \doteq 180^{cfs}$ (SEE p. 8)

∴ SPILLWAY CAPACITY IS (±) 72% THE OUTFLOW AT ½ PMF AND (±) 13% THE OUTFLOW AT PMF

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Project NON-FEDERAL DAMS INSPECTION — Sheet 11 of 15
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SILVER LAKE DAM

I,5) SUMMARY

a) PEAK INFLOW: $Q_{P_1} = \frac{1}{2}$ PMF $\approx$ 1700 CFS Q'_{P_1} = PMF $\approx$ 3400 CFS

b) PEAK OUTFLOW: $Q_{P_3} \approx$ 350 CFS $Q'_{P_3} \approx$ 1430 CFS

c) SPILLWAY MAX. CAPACITY: $Q_S \approx$ 180 CFS OR (±)72% OF Q_{P_3} AND (±)13% OF Q'_{P_3}

THEREFORE, AT SDF = ½ PMF, THE DAM IS OVERTOPPED (±)0.3' (W.S. ELEV. 154.8' MSL) OR TO A SURCHARGE ABOVE THE SPILLWAY CREST OF (±)4.8'

AT SDF = PMF, THE DAM IS OVERTOPPED (±) 2' (W.S. ELEV. 156.5' MSL) OR TO A SURCHARGE ABOVE THE SPILLWAY CREST OF (±) 6.5'.

NOTE: THE SILVER LAKE DAM DROP INLET SPILLWAY AND OUTLET CONDUIT COULD POTENTIALLY BE SUBJECT TO SERIOUS OBSTRUCTION AND CLOGGING BY FLOATING OR DROPPED DEBRIS AT THE INLET. ANY DEGREE OF OBSTRUCTION AND/OR CLOGGING WILL CONSEQUENTLY CURTAIL OR REDUCE THE OUTLET FLOW AND INCREASE TO SOME EXTENT THE SURCHARGE. HOWEVER, BECAUSE OF THE OVERALL LIMITED CAPACITY OF THE EXISTING OUTLET STRUCTURE, THE EXPECTED INCREASE IN THE ESTIMATED OVERTOPPING DEPTHS IS RELATIVELY SMALL, EVEN IN CASE OF TOTAL CLOGGING. UNDER THESE CONDITIONS, THE EXPECTED SURCHARGES ARE (±) 5.6' AND (±) 6.6' FOR ½ PMF AND PMF TEST FLOODS, RESPECTIVELY.

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Project NON-FEDERAL DAMS INSPECTION Sheet 12 of 15
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SILVER LAKE DAM

II) DOWNSTREAM FAILURE HAZARD

1) PEAK FLOOD AND STAGE IMMEDIATELY D/S FROM DAM:

a) BREACH WIDTH:

i) MID-HEIGHT (±) ELEV. ≅ 147' MSL $\left(154.5 - \frac{*15}{2} = 147' \text{MSL}\right)$

* SEE PP. 1 & 2 OF THESE COMPUTATIONS.

∴ ii) APPROX. MID-HEIGHT LENGTH: $\ell \cong 100'$ ((±) FROM C.E. SURVEY MAP)

iii) BREACH WIDTH (SEE NED-ACE D/S DAM FAILURE GUIDELINES):

$W = 0.4 \times 100 = 40'$ ∴ ASSUME $W_b = \underline{40'}$ (MAX.)

b) PEAK FAILURE OUTFLOW (Q_p)

ASSUME SURCHARGE TO TOP OF DAM; THEREFORE,

i) HEIGHT AT TIME OF FAILURE: $Y_0 = 15'$

ii) SPILLWAY DISCHARGE: $Q_S \cong 180^{CFS}$

iii) BREACH OUTFLOW (Q_b):

$$Q_b = \frac{8}{27} W_b \sqrt{g}\, Y_0^{3/2} \cong 3900^{CFS}$$

iv) PEAK FAILURE OUTFLOW (Q_p): $Q_p = Q_S + Q_b = 180 + 3900 = 4087^{CFS}$

SAY, $Q_p \cong \underline{\underline{4100}}^{CFS}$

SILVER LAKE DAM

1 - (CONT'D) PEAK FLOOD AND STAGE IMMEDIATELY D/S FROM DAM:

c) FLOOD APPROX. STAGE IMMEDIATELY D/S OF DAM:

$$y_c = 0.44\,y_0 = 6.6 \cong \underline{\underline{6.5'}}$$

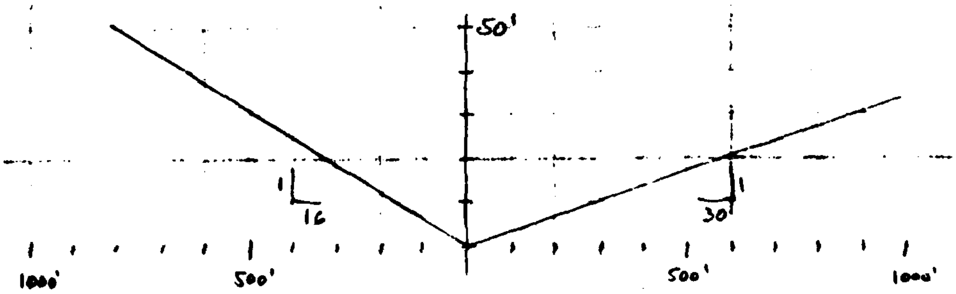
2) ESTIMATE OF D/S DAM FAILURE CONDITIONS AT IMPACT AREA:

(SEE NED-ACE GUIDELINES FOR ESTIMATING D/S DAM FAILURE HYDROGRAPHS)

ASSUME RESERVOIR FULL TO TOP OF DAM AT TIME OF FAILURE.

a) RESERVOIR STORAGE AT TIME OF FAILURE: $S \cong 1480$ ACFT (SEE P. 1)
$S/2 \cong 740$ ACFT

b) TYPICAL D/S CROSS SECTION & RATING CURVES.



ASSUME: i) $n = 0.050$
ii) SLOPE: * $S_0 \cong 0.54\%$
(DROPS 20' in (±) 3700')

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Project NON-FEDERAL DAMS INSPECTION

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Computed By HM

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Date 5/7/79

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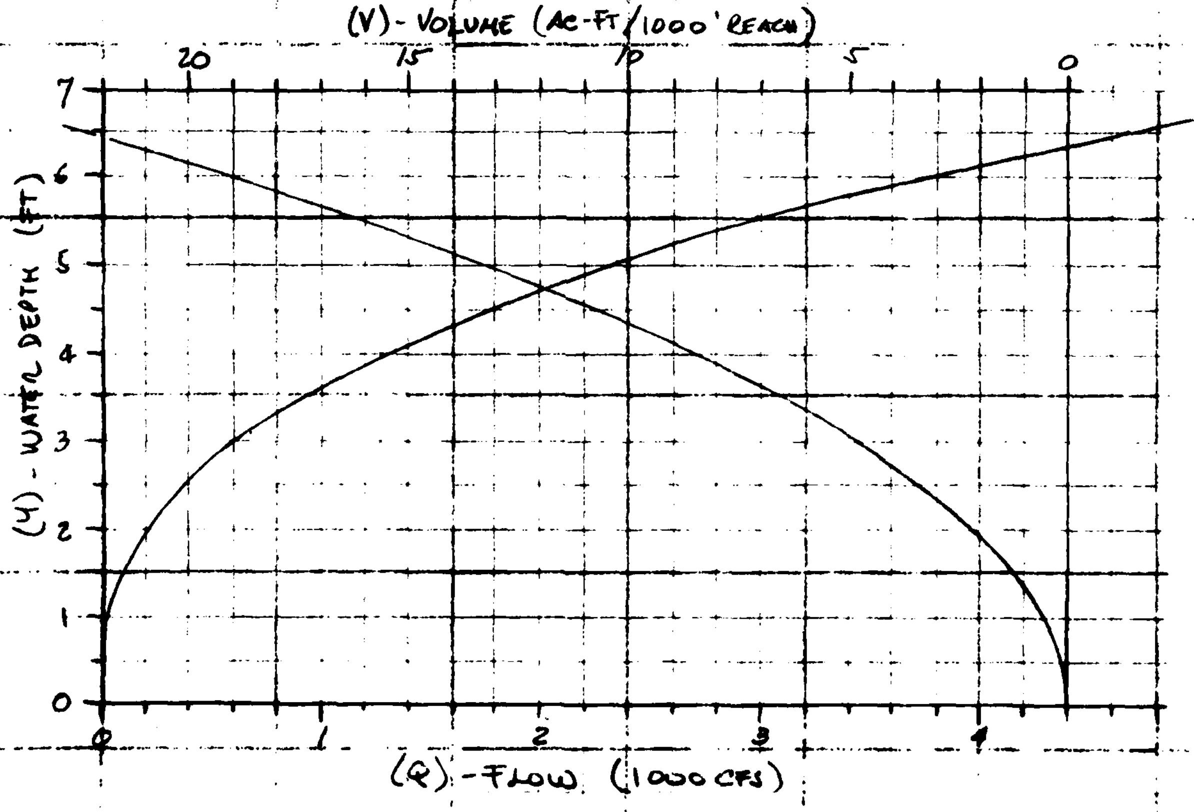
Revisions

SILVER LAKE DAM

2-Cont'd) D/S DAM FAILURE CONDITIONS AT IMPACT AREA

c) RATING CURVE (D/S CROSS SECTION)



d) REACH OUTFLOW (Q_{P2})

i) ASSUME REACH LENGTH $L = 6000'$ (SILVER LAKE TO IMP. AREA (3) GILLS POND)

ii) @ $Q_{P1} = 4100^{CFS}$ ∴ $Y_1 \doteq 6.2'$ $V_1 \doteq 122^{AC\text{-}FT} < \frac{S}{2}$ ok $\left(\frac{S}{2} \doteq 780^{AC\text{-}FT}\right)$

iii) $Q_{P2} = Q_{P1}\left(1 - \frac{V_1}{S}\right) \doteq 3760^{CFS}$ ∴ $Y_2 \doteq 6.0'$ $V_2 \doteq 114^{AC\text{-}FT}$

D-14

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Project NON-FEDERAL DAMS INSPECTION Sheet 15 of 15
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SILVER LAKE DAM

2, d-Cont'd) REACH OUTFLOW (Q_{P3})

iv) AVE VOLUME IN REACH: $V_{AVE} \approx 118$ AC-FT

v) $Q_{P3} \approx 3770$ CFS ∴ $Y_3 \approx 6.0'$ (AT IMPACT AREA)

e) APPROXIMATE STAGE JUST BEFORE FAILURE:

i) $Q = Q_S \approx 180$ CFS

ii) THEREFORE, THE STAGE FOR THE FULL SPILLWAY FLOW IN THE ASSUMED TYPICAL CROSS SECTION IS OF THE ORDER OF:

$$Y \approx 1.9'$$

f) APPROXIMATE RISE IN STAGE AFTER FAILURE:

$\Delta Y \approx 6.2 - 1.9 = 4.3'$ SAY, OF THE ORDER OF 4'

3) SUMMARY:

a) PEAK FAILURE OUTFLOW: $Q_{P1} \approx 4100$ CFS

b) REACH OUTFLOW: $Q_{P3} \approx 3800$ CFS

c) AVE. FLOOD DEPTH (STAGE) AFTER FAILURE: $Y_3 \approx 6'$

d) APPROX. STAGE BEFORE FAILURE: $Y \approx 2'$

e) RISE IN STAGE AFTER FAILURE: $\Delta Y \approx 4'$

PRELIMINARY GUIDANCE

FOR ESTIMATING

MAXIMUM PROBABLE DISCHARGES

IN

PHASE I DAM SAFETY

INVESTIGATIONS

New England Division
Corps of Engineers

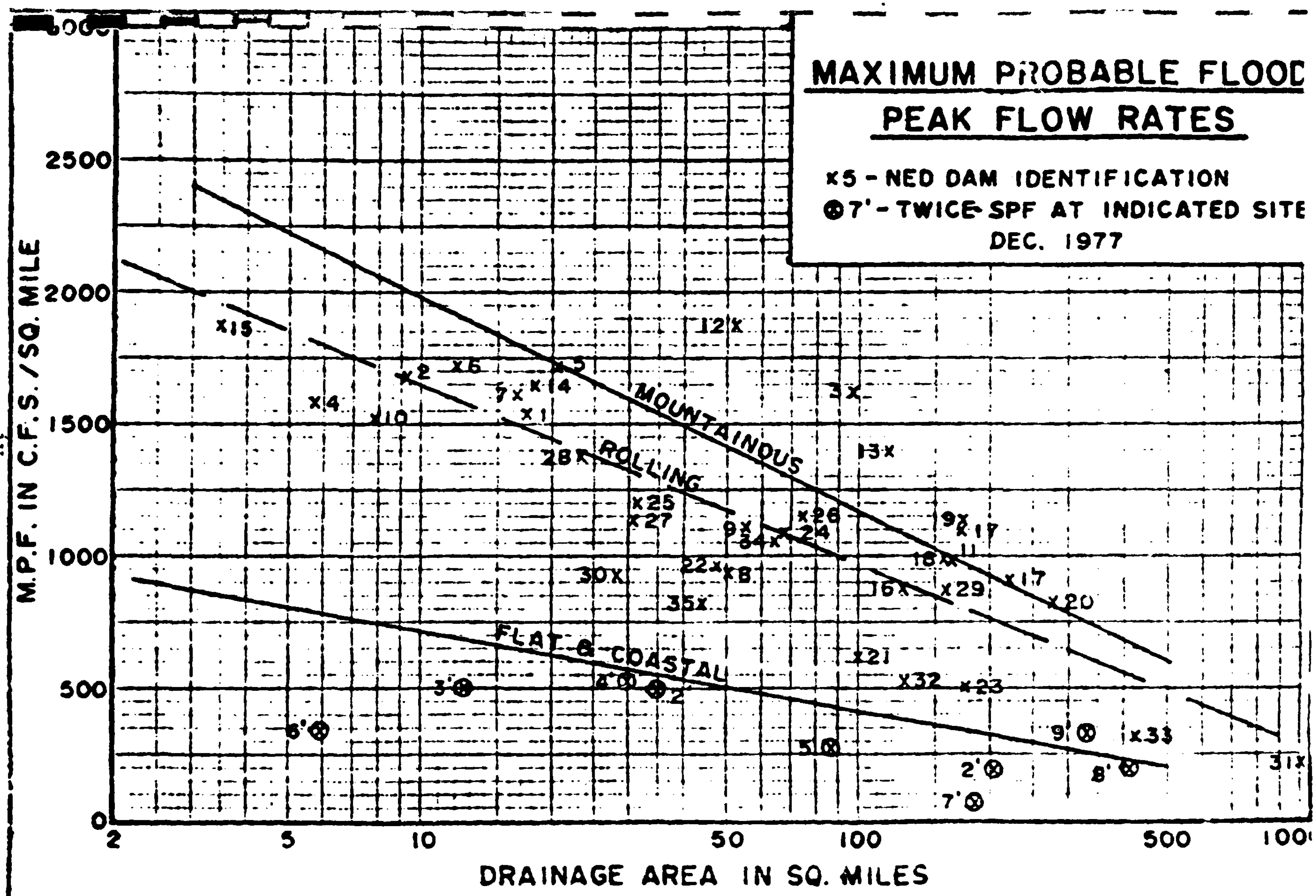
March 1978

MAXIMUM PROBABLE FLOOD INFLOWS
NED RESERVOIRS

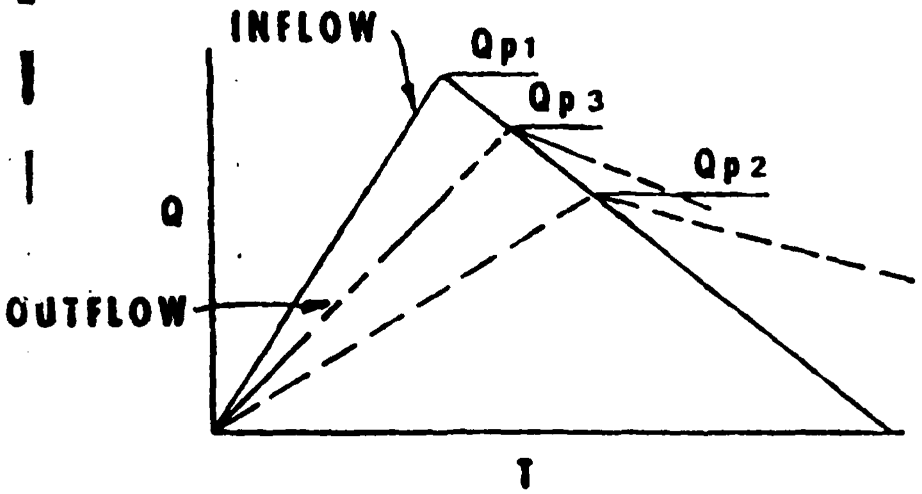
	Project	Q (cfs)	D.A. (sq. mi.)	MPF cfs/sq. mi.
1.	Hall Meadow Brook	26,600	17.2	1,546
2.	East Branch	15,500	9.25	1,675
3.	Thomaston	158,000	97.2	1,625
4.	Northfield Brook	9,000	5.7	1,580
5.	Black Rock	35,000	20.4	1,715
6.	Hancock Brook	20,700	12.0	1,725
7.	Hop Brook	26,400	16.4	1,610
8.	Tully	47,000	50.0	940
9.	Barre Falls	61,000	55.0	1,109
10.	Conant Brook	11,900	7.8	1,525
11.	Knightville	160,000	162.0	987
12.	Littleville	98,000	52.3	1,870
13.	Colebrook River	165,000	118.0	1,400
14.	Mad River	30,000	18.2	1,650
15.	Sucker Brook	6,500	3.43	1,895
16.	Union Village	110,000	126.0	873
17.	North Hartland	199,000	220.0	904
18.	North Springfield	157,000	158.0	994
19.	Ball Mountain	190,000	172.0	1,105
20.	Townshend	228,000	106.0(278 total)	820
21.	Surry Mountain	63,000	100.0	630
22.	Otter Brook	45,000	47.0	957
23.	Birch Hill	88,500	175.0	505
24.	East Brimfield	73,900	67.5	1,095
25.	Westville	38,400	99.5(32 net)	1,200
26.	West Thompson	85,000	173.5(74 net)	1,150
27.	Hodges Village	35,600	31.1	1,145
28.	Buffumville	36,500	26.5	1,377
29.	Mansfield Hollow	125,000	159.0	786
30.	West Hill	26,000	28.0	928
31.	Franklin Falls	210,000	1000.0	210
32.	Blackwater	66,500	128.0	520
33.	Hopkinton	135,000	426.0	316
34.	Everett	68,000	64.0	1,062
35.	MacDowell	36,300	44.0	825

MAXIMUM PROBABLE FLOWS
BASED ON TWICE THE
STANDARD PROJECT FLOOD
(Flat and Coastal Areas)

	River	SPF (cfs)	D.A. (sq. mi.)	MPF (cfs/sq. mi.)
1.	Pawtuxet River	19,000	200	190
2.	Mill River (R.I.)	8,500	34	500
3.	Peters River (R.I.)	3,200	13	490
4.	Kettle Brook	8,000	30	530
5.	Sudbury River.	11,700	86	270
6.	Indian Brook (Hopk.)	1,000	5.9	340
7.	Charles River.	6,000	184	65
8.	Blackstone River.	43,000	416	200
9.	Quinebaug River	55,000	331	330


MAXIMUM PROBABLE FLOOD
PEAK FLOW RATES
x5 - NED DAM IDENTIFICATION
⊗7' - TWICE SPF AT INDICATED SITE
DEC. 1977
MOUNTAINOUS
ROLLING
FLAT & COASTAL
M.P.F. IN C.F.S. / SQ. MILE
DRAINAGE AREA IN SQ. MILES
0
500
1000
1500
2000
2500
2
5
10
50
100
500
1000

ESTIMATING EFFECT OF SURCHARGE STORAGE ON MAXIMUM PROBABLE DISCHARGES



STEP 1: Determine Peak Inflow (Q_{p1}) from Guide Curves.

STEP 2: a. Determine Surcharge Height To Pass "Q_{p1}".

b. Determine Volume of Surcharge ($STOR_1$) In Inches of Runoff.

c. Maximum Probable Flood Runoff In New England equals Approx. 19", Therefore

$$Q_{p2} = Q_{p1} \times \left(1 - \frac{STOR_1}{19}\right)$$

STEP 3: a. Determine Surcharge Height and "$STOR_2$" To Pass "Q_{p2}"

b. Average "$STOR_1$" and "$STOR_2$" and Determine Average Surcharge and Resulting Peak Outflow "Q_{p3}".

SURCHARGE STORAGE ROUTING SUPPLEMENT

STEP 3: a. Determine Surcharge Height and "$STOR_2$" To Pass "Qp_2"

b. Avg "$STOR_1$" and "$STOR_2$" and Compute "Qp_3".

c. If Surcharge Height for Qp_3 and "$STOR_{AVG}$" agree O.K. If Not:

STEP 4: a. Determine Surcharge Height and "$STOR_3$" To Pass "Qp_3"

b. Avg. "Old $STOR_{AVG}$" and "$STOR_3$" and Compute "Qp_4"

c. Surcharge Height for Qp_4 and "New $STOR_{Avg}$" should Agree closely

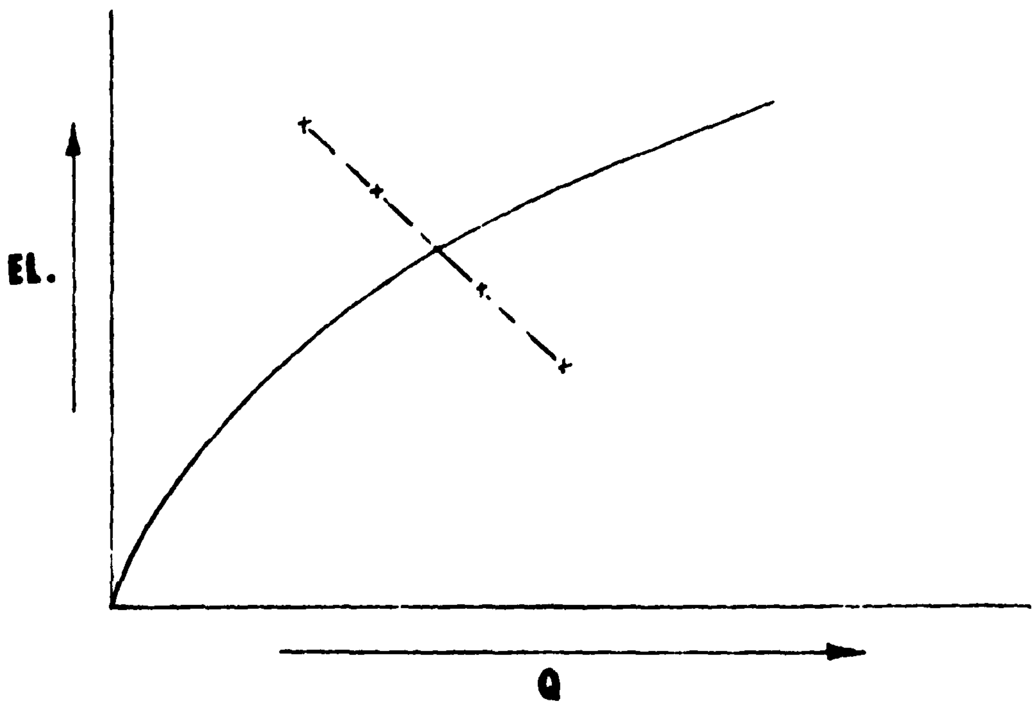
SURCHARGE STORAGE ROUTING ALTERNATE

$$Q_{p2} = Q_{p1} \times \left(1 - \frac{STOR}{19}\right)$$

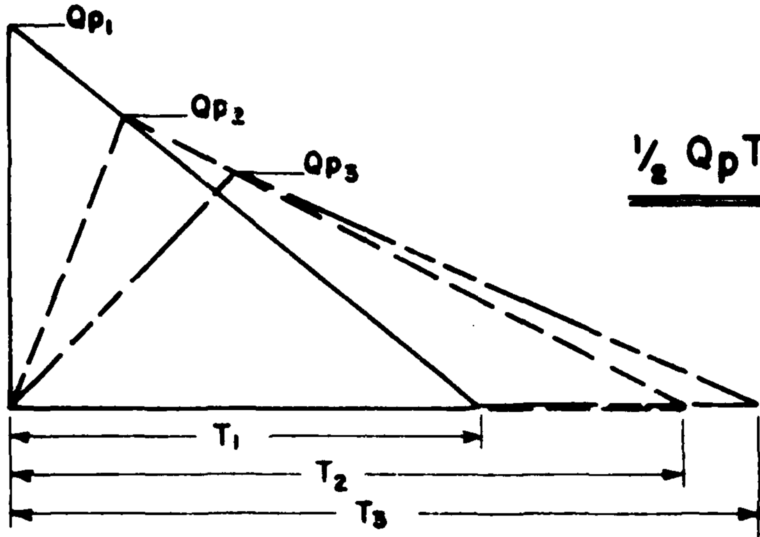
$$Q_{p2} = Q_{p1} - Q_{p1}\left(\frac{STOR}{19}\right)$$

FOR KNOWN Q_{p1} AND 19'' R.O.

Q_{p2}	STOR	EL.



"RULE OF THUMB" GUIDANCE FOR ESTIMATING DOWNSTREAM DAM FAILURE HYDROGRAPHS



$$\frac{1}{2} Q_p T = 12\,S$$

STEP 1: DETERMINE OR ESTIMATE RESERVOIR STORAGE (S) IN AC-FT AT TIME OF FAILURE.

STEP 2: DETERMINE PEAK FAILURE OUTFLOW (Q_{p1}).

$$Qp_1 = \frac{8}{27}\, W_b \sqrt{g}\; Y_o^{3/2}$$

W_b = BREACH WIDTH - SUGGEST VALUE NOT GREATER THAN 40% OF DAM LENGTH ACROSS RIVER AT MID HEIGHT.

Y_o = TOTAL HEIGHT FROM RIVER BED TO POOL LEVEL AT FAILURE.

STEP 3: USING USGS TOPO OR OTHER DATA, DEVELOP REPRESENTATIVE STAGE-DISCHARGE RATING FOR SELECTED DOWNSTREAM RIVER REACH.

STEP 4: ESTIMATE REACH OUTFLOW (Q_{p2}) USING FOLLOWING ITERATION.

A. APPLY Q_{p1} TO STAGE RATING, DETERMINE STAGE AND ACCOPMANYING VOLUME (V_1) IN REACH IN AC-FT. (NOTE: IF V_1 EXCEEDS 1/2 OF S, SELECT SHORTER REACH.)

B. DETERMINE TRIAL Q_{p2}.

$$Qp_2(\text{TRIAL}) = Qp_1\left(1 - \frac{V_1}{S}\right)$$

C. COMPUTE V_2 USING Q_{p2} (TRIAL).

D. AVERAGE V_1 AND V_2 AND COMPUTE Q_{p2}.

$$Qp_2 = Qp_1\left(1 - \frac{V_{ave}}{S}\right)$$

STEP 5: FOR SUCCEEDING REACHES REPEAT STEPS 3 AND 4.

APRIL 1978

APPENDIX E

INFORMATION AS CONTAINED IN
THE NATIONAL INVENTORY OF DAMS